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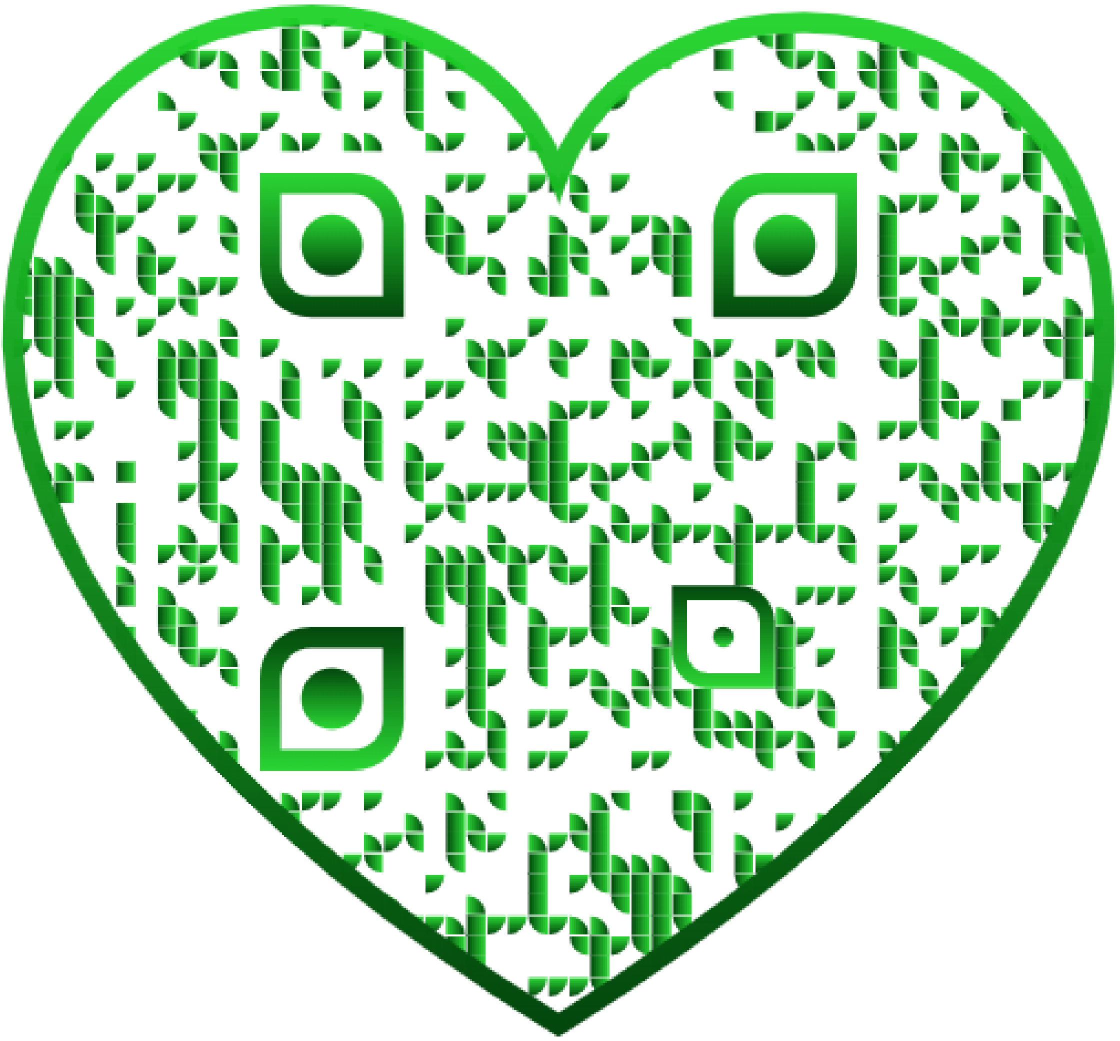
Science Focus

ADHD WHAT WE GOT WRONG AND WHY IT MATTERS

The story behind the surge in cases



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FROM THE EDITOR

Psychology is rife with myths: you only use 10 per cent of your brain; you're either left-brained or right-brained; your brain has a 'learning style'. Culture is littered with ideas that would have any decent psychologist rolling their eyes.

It's the result, I think, of the subject being so young. Psychology was 'officially' born in 1879, when Prof Wilhelm Wundt opened a lab in Leipzig, Germany, to study the mind, insisting that the subject ought to be separated from philosophy and biology. At 146 years old, psychology is no spring chicken, but compared to physics or biology, it's a toddler.

Since the subject is still in its infancy, a lot of the early ideas about human thought and behaviour linger, giving rise to misconceptions about how our brains work. Take the whole left/right brain hypothesis as an example. The theory was drawn from early studies on victims of strokes who would present with language difficulties when the left side of their brain was damaged. This told us that parts of language function lived in this hemisphere. But some would draw the conclusion that perhaps all creativity resided here, and in fact, those with artistic leanings had more active left brains. But thousands of brain scans of patients using today's technology have shown very little difference in the brain activity of different types of thinkers. And yet the idea persists.

While the 'left/right brain' idea is relatively harmless, others can get us into trouble. TV in the 90s taught me that attention deficit hyperactivity disorder (ADHD) was something only kids got – the unruly, fidgety kind that couldn't sit still long enough to do their homework. The trouble is, psychology and the early culture around the condition, naturally oversimplified what was happening. Now, as we learn more about it, those assumptions are crashing into real people's lives. To find out why millions are waking up to the new reality of ADHD, head to page 68.

Daniel Bennett

Daniel Bennett, Editor

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ON THE BBC THIS MONTH...

The Lost Neanderthals
This new documentary follows a team of archaeologists exploring the Mandrin Cave, in southern France. It was there, in 2015, that they discovered the remains of a Neanderthal that may have lived alongside *Homo sapiens*.
Watch now on BBC iPlayer

Tech Life: Keeping Connected
Cables are vital to our modern connected world. But what's the alternative for global, 24-hour communication if they're damaged by natural disaster or war?
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Science in Action: Stephen Hawking gets it right again
In this episode of the weekly round-up of science news, Prof Alberto Vecchio explains how new evidence has confirmed the famous physicist's theory on merging black holes.
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Unravelling the mysteries of wombat poo
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Jack, a medical doctor and science writer, delves into the misconceptions around ADHD and what's fuelling the dramatic rise in diagnoses among adults. → p68

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There's a problem with electric vehicles that few people want to address. Motoring journalist Quentin reveals the straightforward solution. → p34

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Should you be worried about your cortisol levels? Yes, according to social media. Ginny, a science writer, investigates to see if the answer is that simple. →p28

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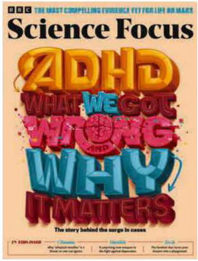

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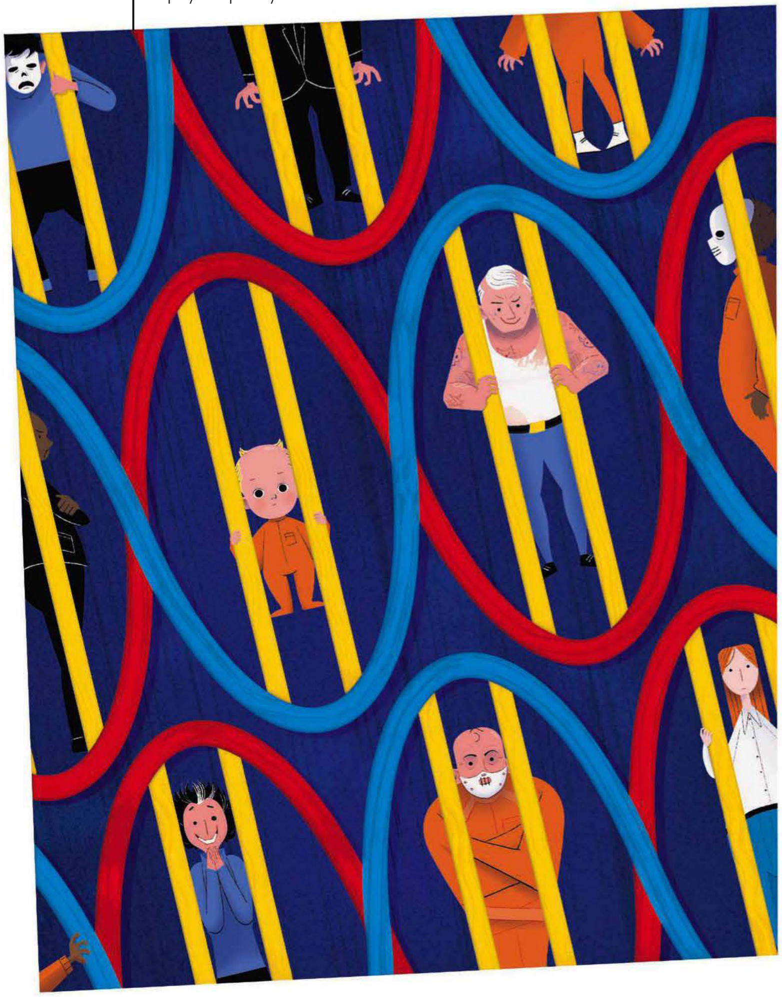

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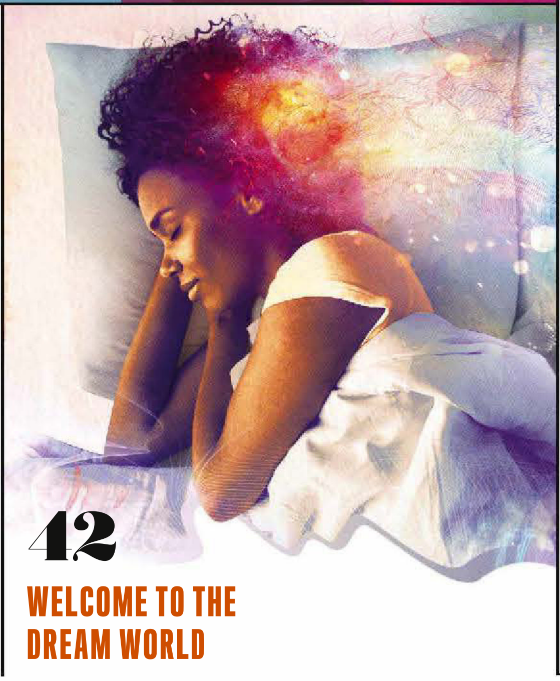

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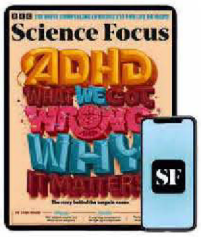

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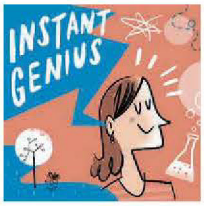

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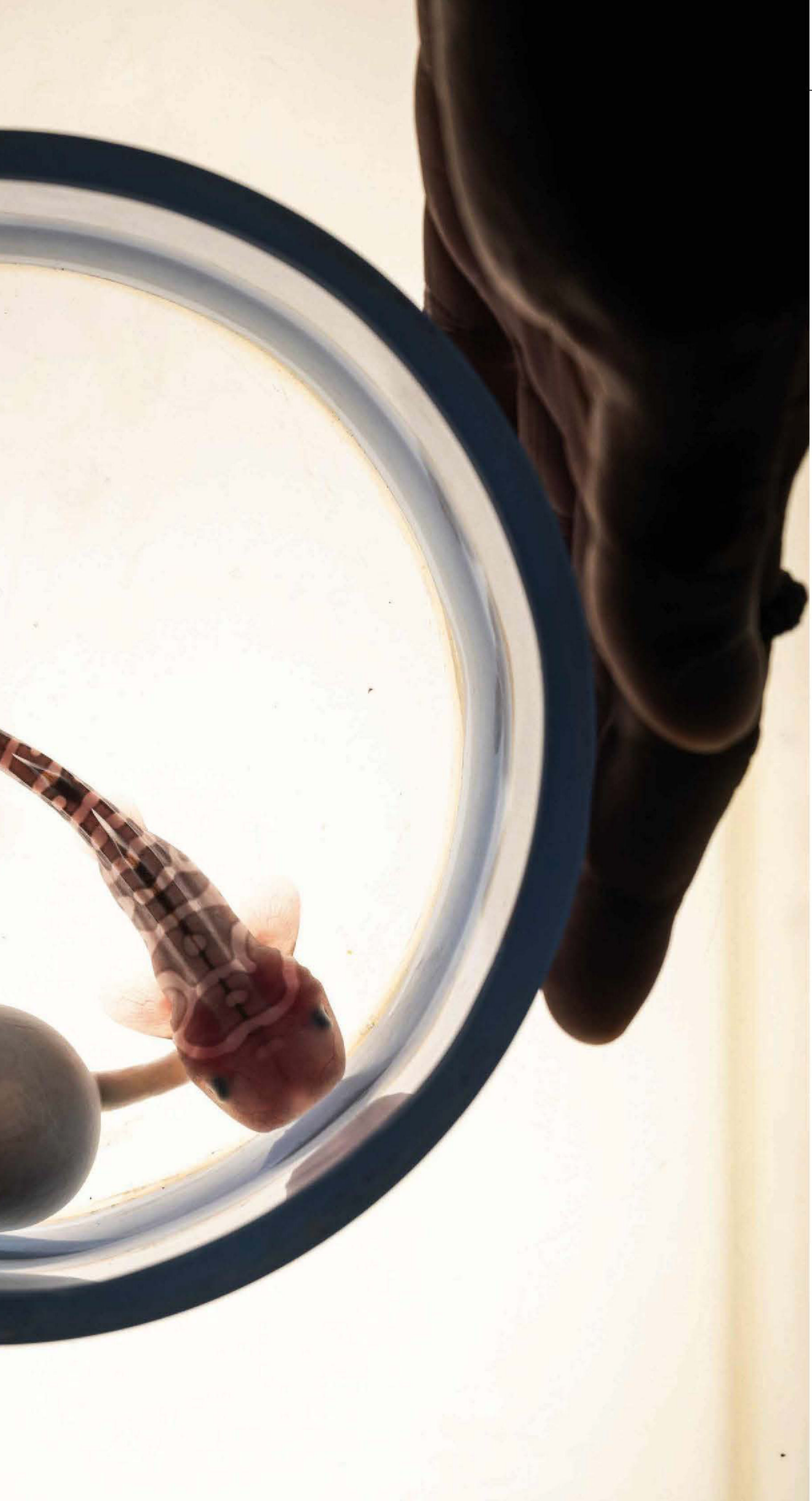

EYE OPENER

Baby shark

PHUKET, **THAILAND**

The alien-looking organism inside this glass jar goes by a variety of names. In scientific circles, it's known as *Stegostoma tigrinum*. Informally, however, people refer to it as an Indo-Pacific leopard shark. Or at least they do when it's a fully grown, 2.5m-long (8ft) adult and has developed its distinctive spotted skin pattern. As a juvenile, though, it has bold brown and white stripes – a pattern that inspired its common name: the zebra shark. The one you see here, however, is just an embryo.

It's been removed from its protective egg case for a rearing experiment – part of the shark breeding programme at Thailand's Aquaria Phuket. The grey ball it's attached to is the yolk sac, which contains all the nutrients the tiny shark needs to grow. Normally, this would be absorbed by the shark and have disappeared by the time it hatches.

As a species, the Indo-Pacific leopard shark is having a tough time. It's classified as endangered by the International Union for the Conservation of Nature. But Aquaria Phuket offers hope: 40 pups have been produced through its breeding programme since 2023 and the aquarium has been in talks with government bodies about reintroducing them into the wild. Don't worry: they mostly eat crustaceans, fish and sea snakes.

SIRACHAI ARUNRUGSTICHAI/OCEAN PHOTOGRAPHER OF THE YEAR

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EYE OPENER

A truck load

GUIZHOU PROVINCE, **CHINA**

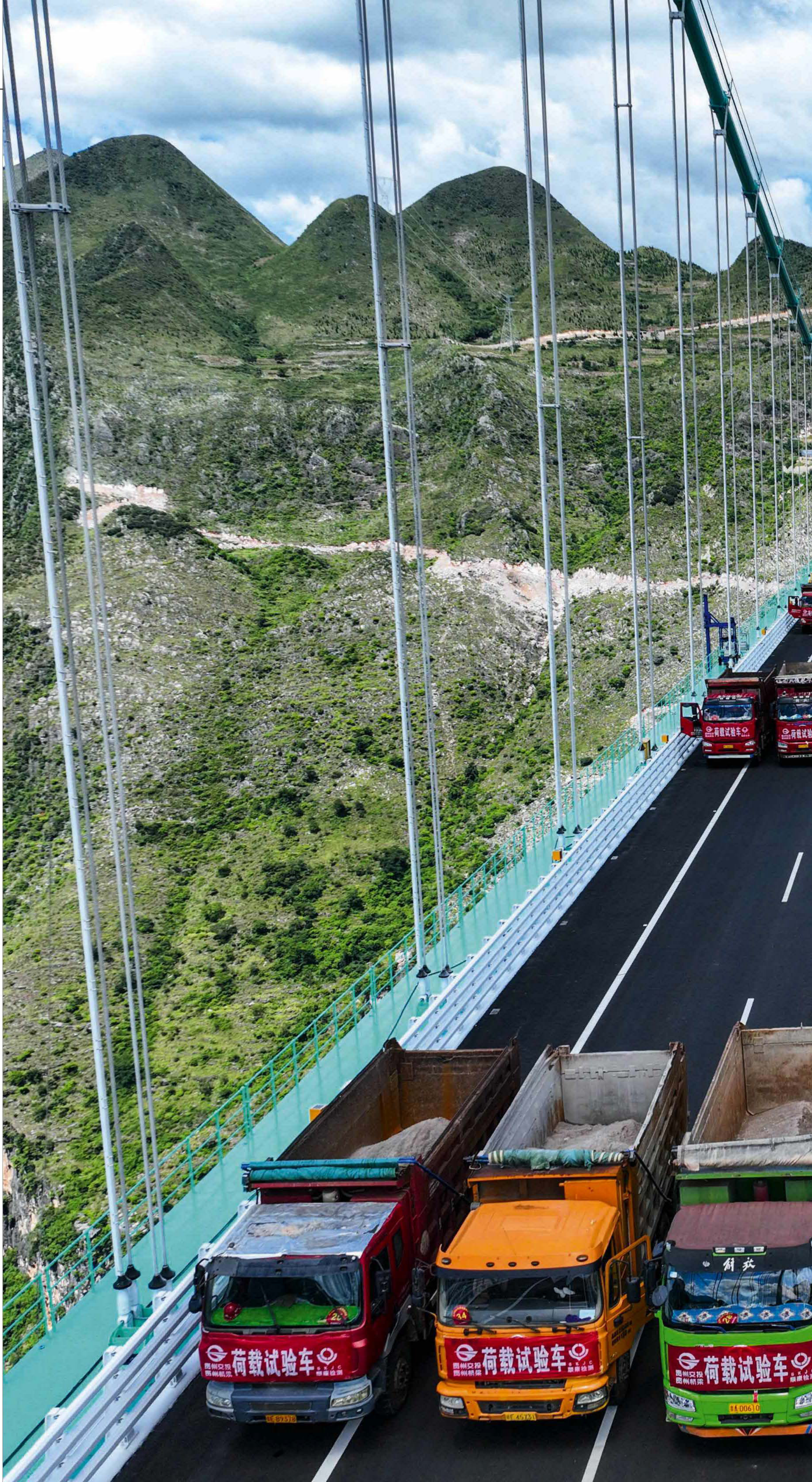
No, this isn't an oddly ordered traffic jam or a well-organised truckers' protest. It's a load test for what's just become the world's highest bridge.

The Huajiang Grand Canyon Bridge has been built in southwest China's Guizhou Province and is suspended a dizzying 625m (2,050ft) above the Beipan River.

Not sure how high that is? Imagine the Shard, the tallest building in western Europe and a prominent feature of London's skyline. Now duplicate it and stand one on top of the other. You could place that pairing underneath the Huajiang Grand Canyon Bridge and still have room to spare.

Static load tests were carried out on the new bridge in August to ensure it can support the weight of the traffic expected to use it. To start with, 18 trucks were driven onto its deck and parked to see if it would hold. After that, bridge engineers tried 48 trucks. Then they tried the 96 you see here, which together weighed in at a monstrous 2,994 tonnes.

Dynamic load tests were also undertaken to make sure flowing traffic wouldn't unsettle the bridge. So far, so good: the bridge has passed all its tests and, at the time of writing, was due to open in September.



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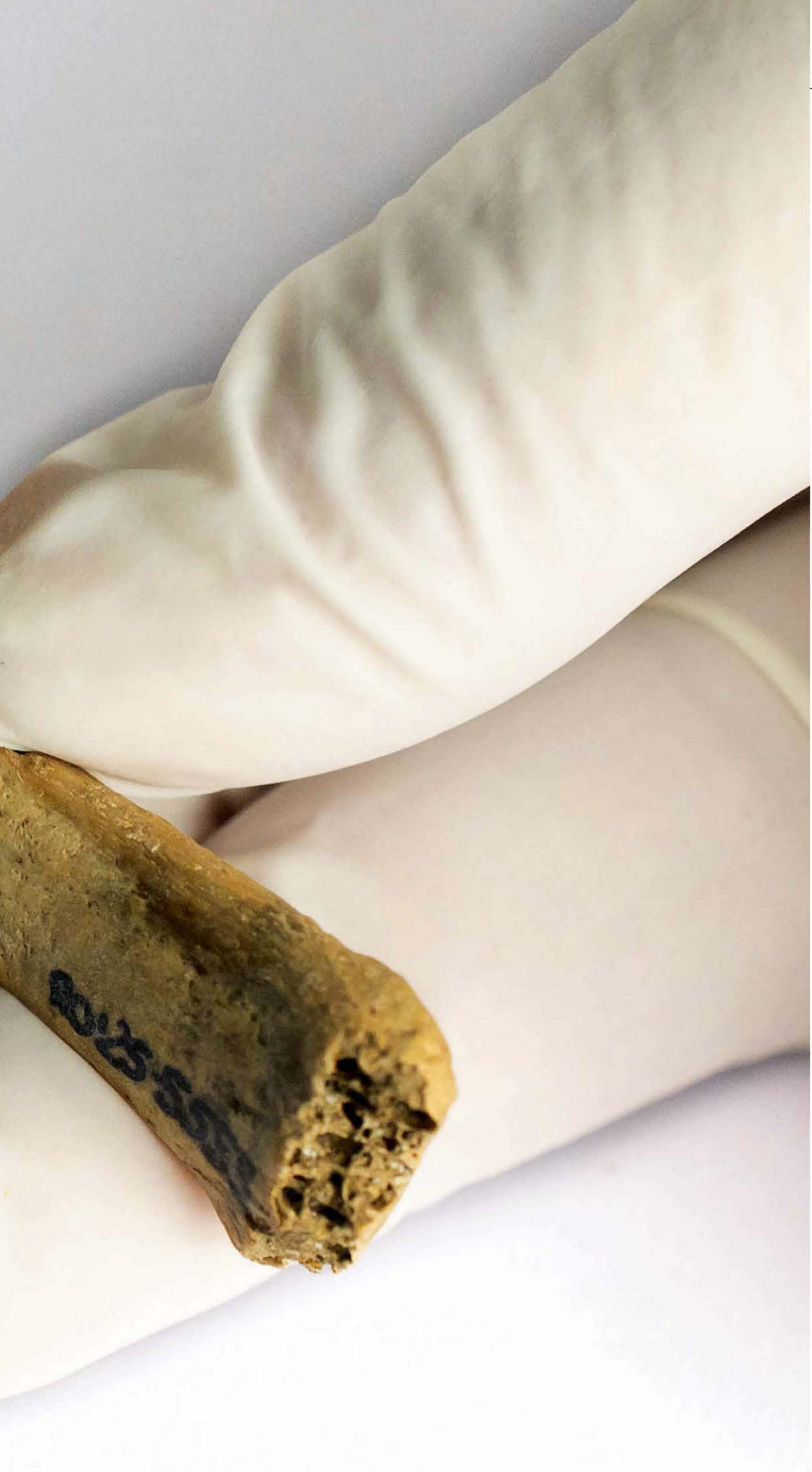

EYE OPENER

A history of violence

GIRONA, **SPAIN**

How's this for a poke in the ribs? It's an arrowhead that was shot into someone's ribcage around 4,000 years ago. What makes it unusual is that the wound clearly wasn't fatal – new bone has grown around the arrowhead, indicating that the victim not only survived the injury, but lived long enough for a significant amount of healing to take place.

The unique artefact was discovered in the Roc de les Orenetes, a cave nestled 1,800m (5,900ft) above sea level in the Catalan Pyrénées of northeast Spain. The cave was used as a burial site during the Bronze Age and archaeologists have been excavating it since 2019. This is the latest evidence of conflict they've discovered there (the position of the arrow in the rib shows that it was fired at the victim from behind, which is more indicative of an attack, than an accident).

The impaled rib is now on its way to Spain's National Research Centre for Human Evolution for X-rays, before being sent on to labs in Barcelona and the US for further analysis. It's hoped the investigations will shed light on the person the rib belonged to, their way of life and why they wound up getting shot.

MARIA D GUILLÉN / IPHES-CERCA

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LETTER OF THE MONTH

On your left

In your Q&A article on sleep positions, 'What's the best position to sleep in?' (July, p86), Dr Nish Manek mentions that "There's some evidence that left-side sleeping may reduce acid reflux compared to the right." As a diagnostic radiologist, I wanted to write in and confirm this.

I can tell you from having performed thousands of examinations that if I wanted to elicit reflux (specifically gastro-oesophageal reflux, which is associated with clinical symptoms of 'heartburn'), all I had to do was turn the patient on to their right side and voilà! Fluid from their stomach would reflux into their oesophagus.

This is counterintuitive, as on your left side, fluid moves back towards the upper part of the stomach and into the oesophagus. But, in my experience, more often than not, turning the patient on to their right resulted in reflux.

I would therefore say, that if you have a tendency to reflux at night, you're better off laying on your left side than on your right.

Allan M Haggar, MD, FACR, Chicago, Illinois

WRITE IN!

The writer of next issue's Letter of the Month will receive **two hardback popular science books**: *Seven Brief Lessons on Physics* and *Butterflies of the World*.

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Back to front

Dr Nish Manek's answer to 'What's the best position to sleep in?' (July, p86) didn't mention stomach sleepers. Four years ago, I fractured my leg and was forced to sleep on my back after 87 years of sleeping on my stomach. It made dropping off more difficult, but once my leg was better and I flipped back to my front, my body knew it was 'lights out'.

Carol Dykstra, Braintree, Massachusetts

Dr Nish Manek replies… For many people, the body seems to 'know' the position in which it feels most at ease, and that familiarity can be strongly linked to drifting off more easily.

Stomach sleeping can put extra strain on the neck and lower back. But if it's comfortable and hasn't caused you problems, it's usually fine to continue. The main thing is that you're getting good sleep – the position that allows you to do that, is the right one for you.

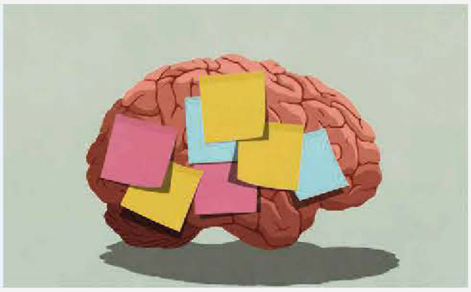
Mental notes

I was reading Dr Christian Jarrett's 'Six science-backed ways to improve your memory' (Summer, p62) and it got me thinking about how I experience memories.

I'm good at remembering facts and stories, but when it comes to my personal history, my memory is very patchy. It's as if I had written a handful of notes with short blurbs of what happened. All words, no pictures.

I've since learned this is linked to aphantasia and is called Severely Deficient Autobiographical Memory. Now I just need to remember where I read about it so I can find out more.

Martyn Kilbryde, via email



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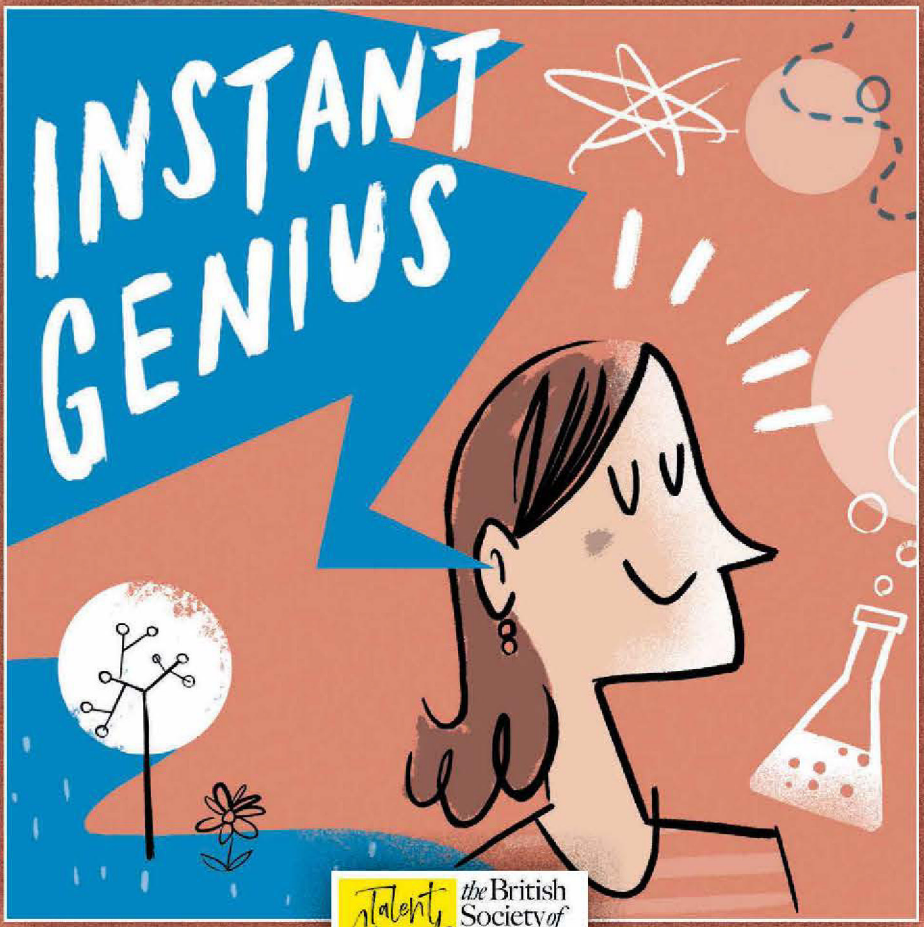

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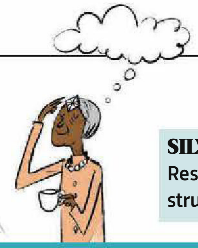
QUEEN KONG
Female gorillas can overpower males twice their size **p20**

GUT REACTION
Study finds link between insomnia and our gut microbiome **p22**



SILVER SECRETS
Research reveals the brain structures of 'super-agers' **p23**

NEWS FROM THE FRONTIERS OF SCIENCE

DISCOVERIES

SPACE

'Clearest sign' of alien life on Mars found by NASA

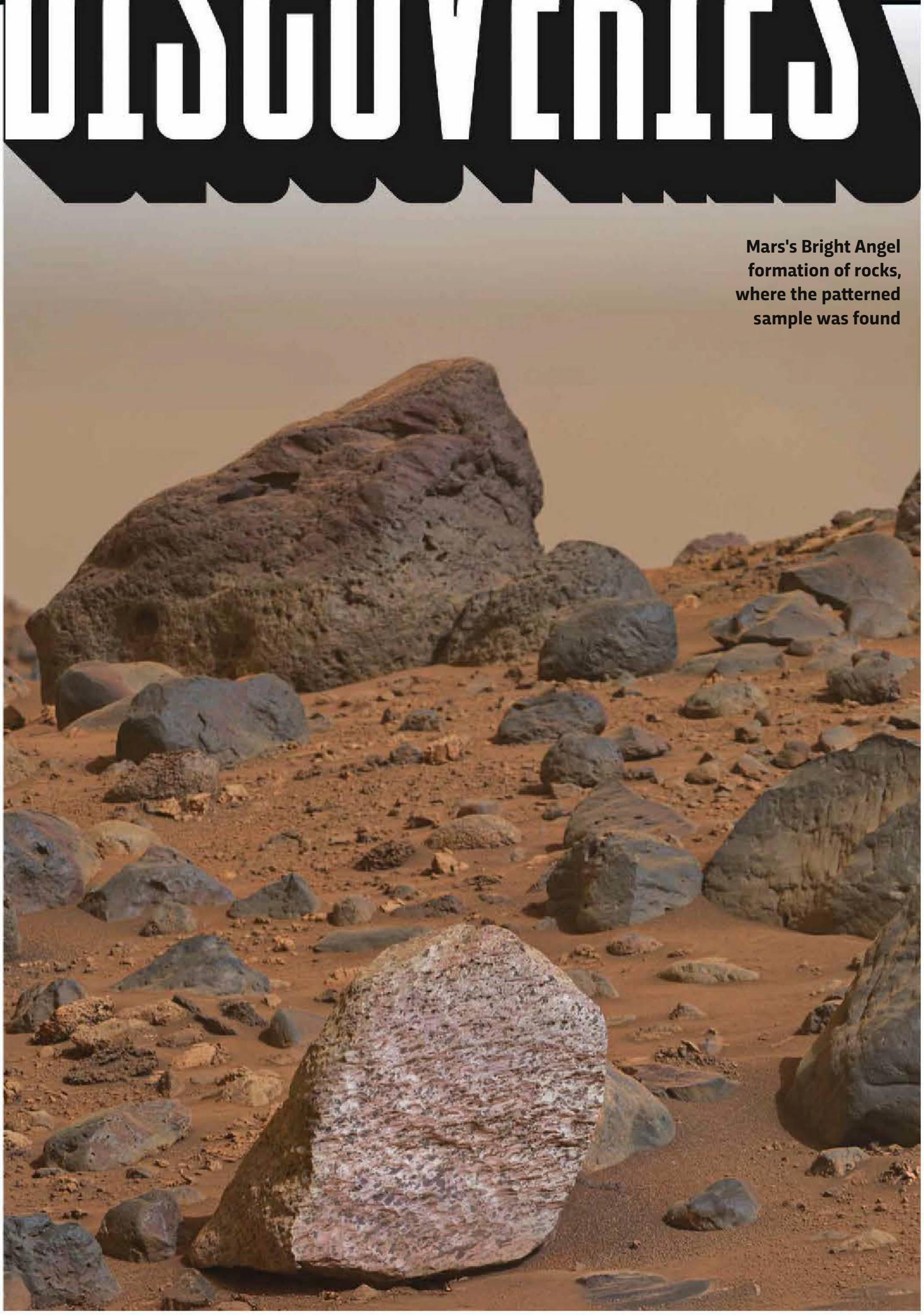
Strange 'leopard spot' markings on a Martian rock could finally be the sign we've been waiting for that alien microbes once lived on the Red Planet

A detailed study of rocks on the Red Planet has revealed intricate patterns resembling leopard spots – "the clearest sign of life we've ever found on Mars," according to NASA's acting administrator Sean Duffy.

The rock, thought to be around 3.5 billion years old, was discovered by NASA's Perseverance rover in July 2024. Ever since, planetary scientists have been investigating possible explanations for what could have created the markings.

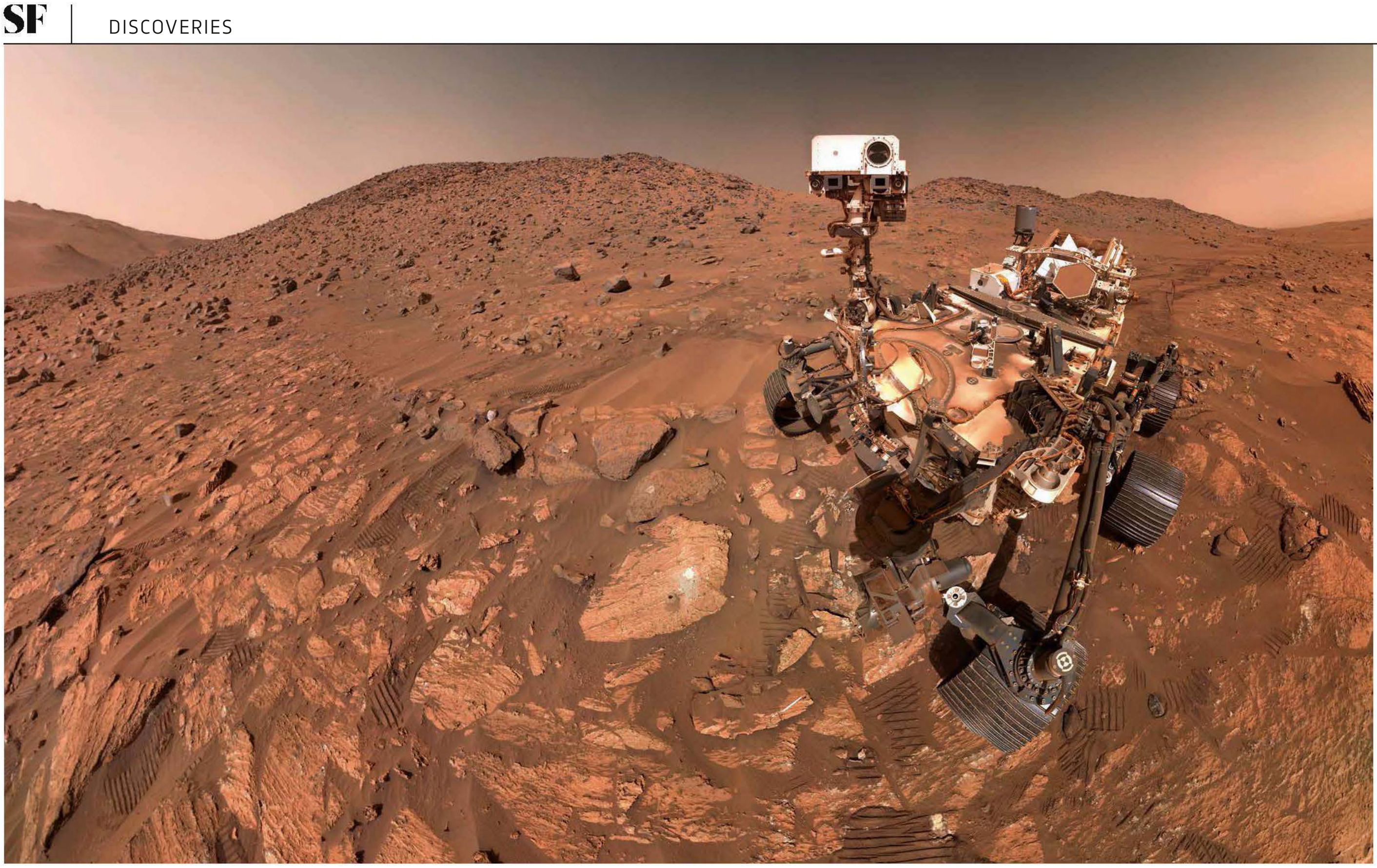
While the patterns may have formed through geological processes, the scientists explained in a recent *Nature* paper that ancient Martian microbes are the current leading theory behind the leopard-patterned rock.

In the hope of obtaining a more definitive answer, Perseverance has taken and stored a fragment of the rock. If all goes to plan, this sample



Mars's Bright Angel formation of rocks, where the patterned sample was found

NASA/JPL



ABOVE NASA's Perseverance Mars rover took this selfie on 23 July 2024 in the Jezero Crater, where the leopard-patterned rock was found

will be returned to Earth one day, where it can be thoroughly examined for signs of past life.

LEOPARD SPOTS AT BRIGHT ANGEL

Today, Mars is a dry, dead world – but that hasn't always been the case. Until around three billion years ago, Mars's surface was covered with flowing rivers and vast lakes of liquid water.

Here on Earth, wherever you find water, you can expect to find life somewhere nearby. To uncover whether this was also true on Mars, NASA rovers have spent the last 20 years hunting for clues to prove whether the Red Planet was once habitable – or even inhabited.

The Perseverance rover was exploring a region known as Jezero Crater, which was a lake in Mars's distant past. Similar regions on Earth are havens for microbial life.

While exploring an outcrop of rocks known as the Bright Angel formation, Perseverance spotted a rock with a striking pattern resembling leopard spots.

"We took just about every possible observation we could of the [patterned] rock and the Bright Angel formation as a whole," study lead Prof Joel Hurowitz from Stony Brook University, in the US, told *BBC Science Focus*.

Perseverance's cameras were able to capture the patterns in minute detail, while devices known as spectrometers analysed the minerals they were made of. The rover was even able to map out the outcrop's structure below the surface using radar.

"Basically, we threw everything but the kitchen sink at these rocks," said Hurowitz.

The analysis revealed the patterns were created by iron-rich minerals known as vivianite and greigite. On Earth, both minerals are often produced by 'redox reactions', where the microbes exchange electrons with their surroundings.

"On Earth, redox reactions like these are often driven by microbes living in sediment, which derive energy from these reactions to power their metabolic activity," said Hurowitz.

The traces left behind by these reactions then create distinctive patterns in the rocks formed from those sediments.

That doesn't mean it's time to start celebrating the discovery of alien life just yet. There are other ways the leopard spots could have

> "Ultimately, the determination of whether life was involved will require analysis in laboratories on Earth"

NASA/JPL X2

been created without the influence of life. For instance, heat could have also provided the energy needed to drive the same reactions between mud and organic matter to produce the new minerals.

The team couldn't find any sign that the rocks had been heated, however. Nor did the conditions look quite right for any other non-life-based method they investigated. But, Hurowitz cautions, "we can't rule them out completely."

One of the biggest surprises is how relatively young the rock is – just 3.5 billion years old. This means that the patterns formed when Mars was already beginning to dry up. This suggests that the planet may have been habitable for a lot longer than planetary scientists previously thought.

Unfortunately, Perseverance has an entire planet to explore, and has now moved on to search for life elsewhere.

"If we were to return to Jezero in the future, there are follow-up questions we might look to address with the rover payload," says Hurowitz.

"But I suspect that these follow-up measurements wouldn't be able to provide a more definitive answer to the question of whether these features were formed by life.

"Ultimately, the determination of whether life was involved will require analysis in laboratories on Earth."

BRINGING MARS TO EARTH

Luckily, Perseverance is only the first stage of a Mars sample return mission – it's not just inspecting rocks on Mars, but preparing to bring them back to Earth.

Before it left Bright Angel, the rover collected a sample from the rock and stored it along with dozens of similar fragments taken during its time on Mars.

NASA's goal is to mount a follow-up mission alongside the European Space Agency to pick up the samples. They'll then return them to Earth, where they can be analysed in the world's best labs.

After 3.5 billion years, however, it won't be easy to find a 'smoking gun' clue that definitively answers whether the patterns were created by life or not. The researchers will instead look for other signs that microbes might have left behind.

"I think a logical first step would be analysis of the isotopic composition of the iron, sulphur and carbon in the various mineral and organic components of the rock," said Hurowitz.

Isotopes can be thought of as different flavours of the same element. Microbes hold on to some isotopes more than others, so comparing which kinds are on the sample can point towards the presence of life, or at least narrow down the list of alternative options.

"These variations in isotopic composition are key tools in the investigation of biological signals in ancient rocks on Earth, and I suspect that we'd want to apply similar tools to this Martian sample," said Hurowitz.

The plan was to schedule the return mission for the 2030s, but it risks being cancelled after the Trump administration cut NASA's planetary exploration budget.

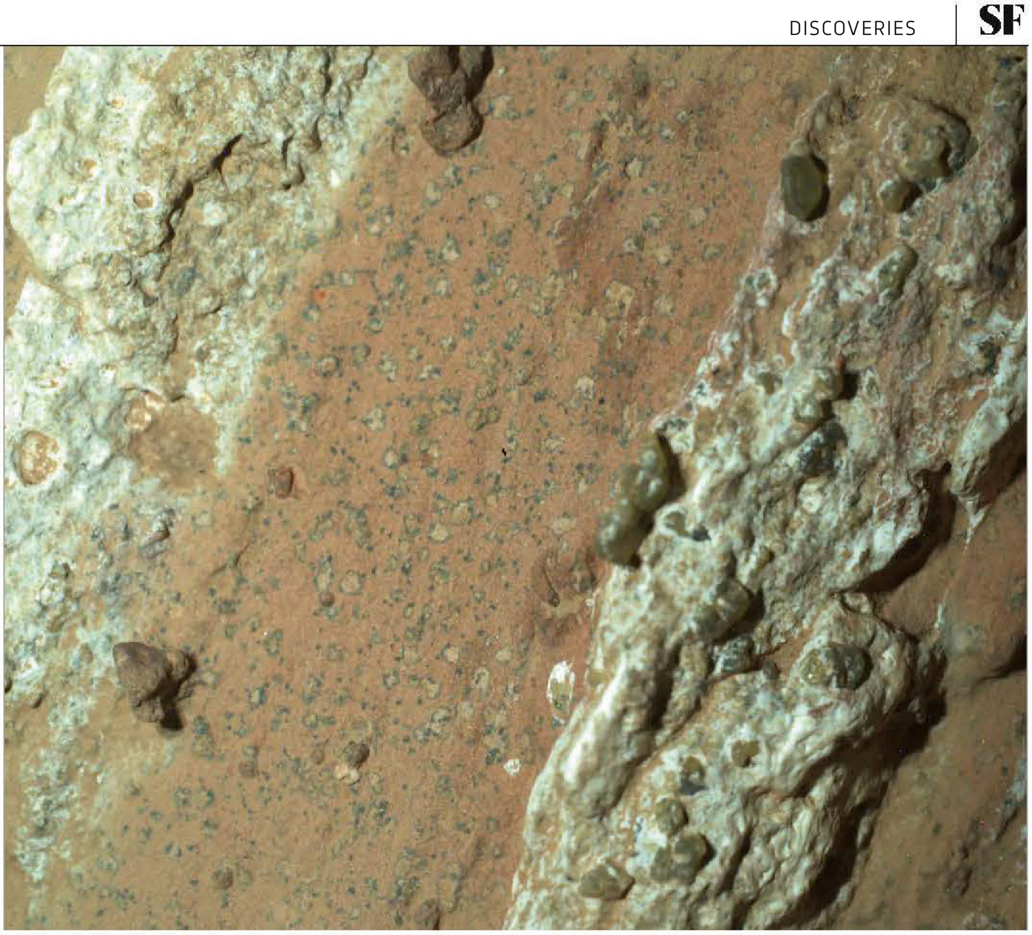
"NASA is looking into how we're getting this sample back or other samples back," a NASA spokesperson told *BBC Science Focus*.

"We've been exploring Mars for 60 years and that's going to continue. We're going to look at our budgets and at our timing for how we can get samples back quickly and inexpensively. We will share any updates as we get them."

"I'm hopeful that these results provide added motivation for a sample return mission," Hurowitz added. "That will allow us to probe this sample in all of the detail that's needed to understand whether it contains a record of life on Mars."

Examining the sample on Earth could also have major implications for life beyond our Solar System.

"If it is life, that means our planet isn't the only one where life evolved," Hurowitz concludes. "If it happened twice, where else did it happen?"



ABOVE Scientists believe that the grey leopard spot pattern running through the centre of this rock was caused by microbe-led redox reactions

ENVIRONMENT

New type of acid rain could threaten life on Earth

This 'forever chemical' is almost impossible to remove from the environment

ILLUSTRATIONS: MATT HOLLAND

"We don't know the long-term consequences of this. But, if a long-term consequence occurs, it will occur on a global scale"

Scientists have warned about a new kind of acid rain that is everywhere, is almost impossible to clean up, and could be a threat to every living thing on the planet.

Trifluoroacetic acid (TFA) – a type of persistent 'forever chemical' – is now present in every rain shower and snowfall on the planet, in concentrations far higher than in previous decades.

It's not yet known exactly what TFA means for human health or the environment, but some researchers have said that the chemical could be an existential threat.

"There's emerging evidence that TFA can disrupt vital Earth system processes, such as mammal embryo development and decreasing soil respiration," Prof Hans Peter Arp, a chemist at the Norwegian University of Science and Technology, told *BBC Science Focus*.

Arp's recent research classified TFA as a planetary threat similar to global warming or the break down of the ozone layer.

Arp continued: "We don't know the long-term consequences of this. But, if a long-term consequence occurs, it will occur on a global scale, as TFA is accumulating globally. And, once the impacts occur, it'll be too late to do anything."

"TFA doesn't degrade naturally, and any technology to remove TFA is extremely costly and can only be used in small amounts."

Arp's paper argued that action needs to be taken now to prevent the rapid accumulation of TFA, before it's identified as an urgent threat.

"In the heating and cooling sector, this means not using gases that lead to TFA formation," said Arp.

"Another step is to transition away from pesticides and pharmaceuticals that create TFA when they degrade."

Some countries have already taken action. Leading the way is Denmark, which banned 23 pesticides in July 2025 because of their links to TFA pollution.

DANGEROUS SIZE

Trifluoroacetic acid is a type of 'forever chemical' – a group of substances so named because they're very difficult to destroy, more formally known as per- and poly-fluoroalkyl substances (PFAS).

Out of all the forever chemicals, TFA is one of the smallest. It can leak into the environment from refrigerants, aerosols, pesticides, air conditioning units, landfills and sewage. And, when larger PFAS break down, they often become TFA.

As it's so small, TFA also dissolves easily in water. That's why it's become one of the most ubiquitous forever chemicals, with rapidly rising levels found in rain – as well as rivers, lakes, groundwater, oceans, leaves, food, and human blood and urine.

Arp said he became interested in the chemical once it was found in "otherwise pristine water resources." This is especially concerning because TFA is considered almost impossible to remove from drinking water.

LOOKING INSIDE

Some scientists have argued that TFA might not be particularly dangerous to humans because – unlike many other forever chemicals – it passes through the body quickly in urine, rather than accumulating inside us.

Arp said that the most recent evidence was clear, however: TFA levels were increasing inside humans, as well as in other animals and in the environment.

"We can see that TFA can enter cells and become building blocks in lipids, proteins and cell walls, which may account for other observations of changes in microbial activity in soils," said Arp.

Scientists like Arp are trying to develop methods of removing TFA from the environment, such as by planting crops that absorb TFA, and then burning these crops at extremely high temperatures, to destroy the chemical.

But Arp said that further research was needed to determine the true threat level of TFA – and, in the meantime, "the first priority is to lower emissions now before the irreversible, global impacts occur."

50%
The amount of fruits and vegetables in the UK that contain PFAS

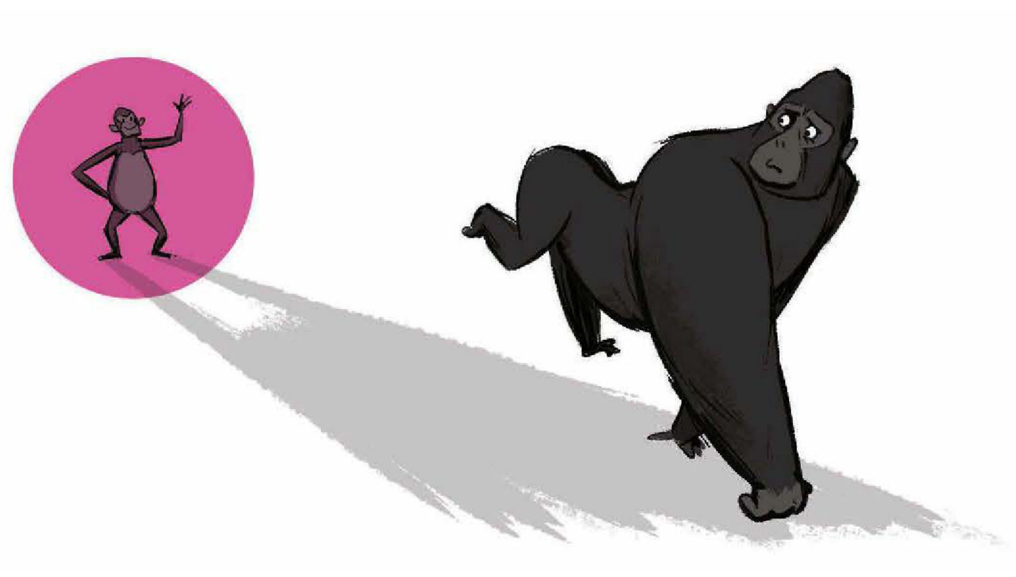
97%
The number of US citizens with PSAS positive blood tests

1,000 YEARS
The time PFAS can exist without breaking down

NATURE

Female gorillas can overpower males twice their size

Primate society is less patriarchal than we previously thought



Despite being roughly half their size, female gorillas can, and frequently do, overpower male gorillas when competing for status and resources, according to a recent study.

This discovery challenges the belief that gorilla society is strongly patriarchal – characterised by male dominance over females – and brings into question the origins of human gender dynamics.

Scientists at the Max Planck Institute for Evolutionary Anthropology, in Germany, and the University of Turku, in Finland, analysed 25 years of data gathered by observing the behaviour of four different groups of gorillas.

Though it's true that gorilla society is hierarchical – each group has one alpha male at the top, and the rest of the gorillas compete for status below him – this new study concluded that gorilla hierarchies are more gender balanced than previously thought.

In fact, 88 per cent of female gorillas outranked at least one adult male in groups with multiple males – mostly in cases where those males were particularly young or senior.

Additionally, when female gorillas engaged in conflicts with non-alpha males, they were victorious more than a quarter of the time, despite being significantly smaller than their opponents.

Senior author Dr Martha Robbins – director of the Bwindi Mountain Gorilla Research Project in Uganda – told *BBC Science Focus* that this success was likely due to the relationship between these high-ranking females and their alpha male.

"The gorillas are aware of their social position and the social dynamics in a group," she said. "These non-alpha males are bigger and physically stronger than the adult females, but they know that they should restrain themselves to avoid aggression from the alpha male. If they want to remain in the group, it's better to acquiesce."

The scientists concluded that these findings had implications for our understanding of gender dynamics in human societies.

The researchers wrote that this suggests the dominance of human men over women is not "an apparent and immediate consequence of evolution," but instead the result of "the flexible social and mating systems of humans."

They cite the example of bonobos – one of our closest living relatives – where males are much bigger than females, but females are dominant over the males. From this, they concluded that it's unlikely humans inherited patriarchy from our primate ancestors.

NEUROSCIENCE

Human brains emit a bizarre glow

Subtle light shines through our skulls in patterns that depends on what we're doing

Our brains glow. We can't see it happen with the naked eye, but scientists can measure extremely subtle light passing through the skull – and a recent study has found that this light changes depending on what we're doing.

All living tissue emits a faint light called ultraweak photon emissions (UPE), and the human brain produces a significant amount of it, due to the high amount of energy it consumes.

"UPE are very weak light signals – trillions of times weaker than a light bulb – that are generated by cells of all kinds throughout the body," senior author Dr Nirosha Murugan, assistant professor of health sciences at Wilfrid Laurier University, in Ontario, Canada, told *BBC Science Focus*.

"Even though UPEs are very weak signals, the brain's

ILLUSTRATIONS: ADAM GALE

SPACE

Largest black hole in the Universe discovered

The black hole grew to its enormous size by consuming all its nearby siblings

> “The black hole itself weighs a staggering 36 billion times the mass of our own Sun”

Astronomers have recently discovered a colossal black hole that has almost 10,000 times more mass than the supermassive black hole at the centre of our Galaxy.

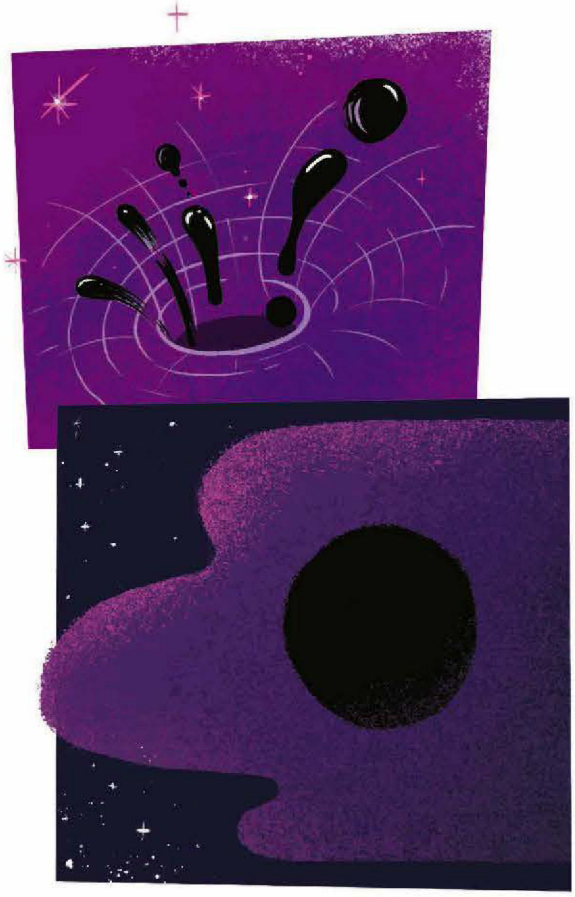
The black hole is located five billion light-years from Earth in the heart of one of the largest known galaxies, the Cosmic Horseshoe. This giant galaxy appears to have gobbled up all the galaxies surrounding it, so that both it and its black hole have grown as large as they possibly can.

The black hole itself weighs a staggering 36 billion times the mass of our own Sun, and is the largest astronomers have ever recorded.

The find was even more remarkable as the black hole isn’t active, meaning it’s not surrounded by a glowing disc of dust. It’s this disc that usually allows astronomers to measure how big a black hole is.

Instead, a new study recently published in *Monthly Notices of the Royal Astronomical Society* used a combination of two existing methods to pin down its size.

“The ‘golden’ method usually relies on stellar kinematics, which involves measuring how stars are moving within a galaxy,” Carlos Melo-Carneiro – the PhD student from Universidade Federal do Rio Grande do Sul, Brazil, who led the study – told *BBC Science Focus*.



But this method is most effective for the galaxies closest to Earth, as our telescopes have better resolution of the region around the black hole.

Since the Cosmic Horseshoe is so distant, the researchers had to rely on a second method. Essentially, this involved measuring the light distorted by the black hole (an effect known as gravitational lensing).

Both the galaxy and black hole reached this scale by merging with their surrounding siblings.

This is how all galaxies grow over time, eventually coming to a point where all the surrounding galaxies that could merge together have done so, resulting in a ‘fossil group’ that can’t grow any larger.

The Cosmic Horseshoe has no other bright galaxies around it, suggesting it has reached this phase.

“This discovery gives us a unique window into the end product of galaxy and black hole formation,” said Melo-Carneiro.

“By studying this system, we can better understand how other galaxies and their supermassive black holes might evolve over cosmic time.”

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energy consumption makes it a great generator of light relative to other organs,” she said.

To investigate whether UPEs could be used to measure brain activity, Murugan’s team recruited 20 adults to sit in a dark room while scientists measured electrical signals and light emitted from their brains.

Participants were instructed to carry out simple instructions, such as opening and closing their eyes. The scientists then compared the electrical signals and UPEs and found a correlation.

“We discovered that light signals detected around the head were related to the brain’s electrical activity during cognitive tasks,” said Murugan. “They oscillate, are complex and carry information.”

Murugan said that measuring this brain light could “change the field of neuroscience” by creating new ways to scan the brain. This light could even be playing a role inside our brains, rather than just being a byproduct of its function.

Murugan said that studying it could “reveal a hidden dimension” of the inner workings of our minds.

Murugan said she hoped the findings would “initiate new conversations about the role of light in brain function.”

HEALTH

Scientists are rethinking the cause of insomnia

A gut reaction might be causing your sleepless nights

Your gut microbes could be causing your insomnia, according to a new study from scientists in China. The study says the reverse is also true: your sleep habits could impact your gut health.

Previous research had already suggested that sleep habits and gut health could be interlinked, but the recent analysis published in the journal *General Psychiatry* indicates that the link might be causal – meaning your sleep might directly influence your gut, and vice versa.

First author Dr Shi Shangyun, from the Affiliated Brain Hospital of Nanjing Medical University, in China, told *BBC Science Focus* that this research had the potential to "reshape understanding of insomnia and inspire interest in microbiome-based research and interventions."

In the future, it's possible that insomnia could be treated via the gut with probiotics (such as sauerkraut), prebiotics (sources of fibre) or faecal transplants, the researchers wrote.

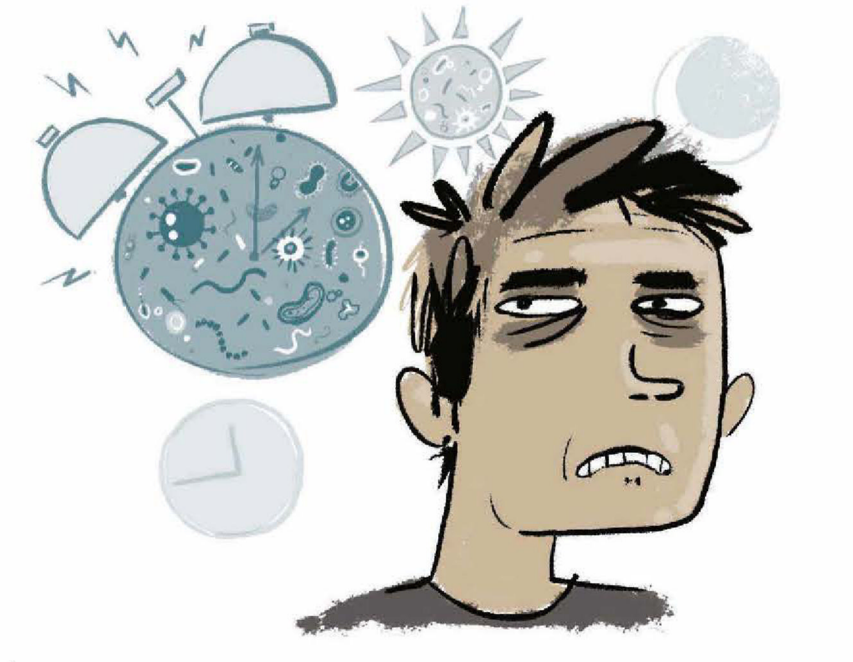
The scientists used a statistical technique called Mendelian randomisation analysis (which uses genetic information to understand cause and effect) to investigate the link between insomnia and the gut.

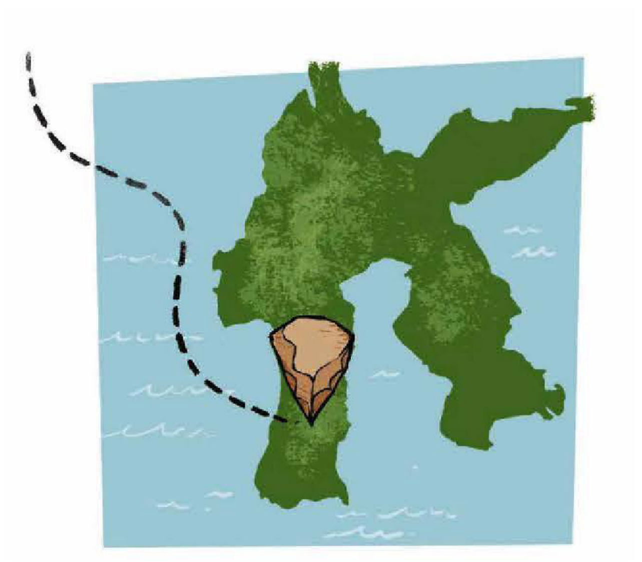
They found certain genes they knew to be linked to insomnia, and calculated whether people with those genes were also more likely to have certain gut microbes. They then did the same in reverse, examining whether people with certain gut microbes were more or less likely to have insomnia.

This involved data from 387,000 people with insomnia, and gut microbiome data from 26,500 people. All the data looked at was European, though, which means that the results might not be relevant to everyone.

The team's analysis suggested that 41 types of gut bacteria were likely to cause insomnia, at least in part.

Overall, the study uncovered a vicious cycle. A variety of gut bacteria might be causing insomnia, but poor sleep might also contribute to a different gut microbiome.





ARCHAEOLOGY

A tiny stone tool may have just rewritten human history

It's not yet clear who left the tool on the island

A discovery on the Indonesian island of Sulawesi has pushed back the timeline of early human sea crossings and deepened the mystery of who made them.

Archaeologists unearthed a stone tool that is at least 1.04 million years old – and possibly as ancient as 1.48 million years old – at Calio, a site in Southern Sulawesi, Indonesia. Because Sulawesi has always been surrounded by deep, fast-moving waters, whoever made the tool would have needed to travel across open ocean.

"This is by far the earliest known evidence for the presence of early humans (hominins) on Sulawesi," Prof Adam Brumm of Griffith University's Australian Research Centre for Human Evolution, who co-led the new study, told *BBC Science Focus*.

"It's now clear there's a pattern of early hominins somehow managing to cross the Wallace Line and giving

ILLUSTRATIONS: ADAM GALE

rise to isolated populations on remote islands.” The Wallace Line is a major biogeographical boundary between the Asian mainland and the islands of Wallacea.

Previous discoveries showed that hominins had reached the nearby island of Flores 1.02 million years ago and Luzon in the Philippines 700,000 years ago. Both islands were later home to small-bodied species such as *Homo floresiensis* and *Homo luzonensis*.

On Sulawesi, however, no hominin fossils have been found, leaving the tool-makers’ identity a mystery.

“We think it was the early Asian hominin species *Homo erectus*,” Brumm said. “We don’t think they were using boats to do this; probably they were being washed out to sea clinging to logs or naturally formed vegetation ‘rafts’, perhaps during tsunamis, and thus the colonisation of the Wallacean islands took place entirely by accident.”

If *Homo erectus* did make it to Sulawesi over a million years ago, they might have followed their own evolutionary path, perhaps becoming just as weird and wonderful as other island-dwelling hominins.

“On Flores and Luzon, fossil discoveries show that the hominins on these islands evolved in isolation into strange new species that were small in size and extremely distinctive,” Brumm said. “We have not yet found any hominin fossils on Sulawesi, so we don’t know if a similar phenomenon happened on that island, but it’s certainly a possibility.”

The next step for Brumm? “Keep digging,” he said. “Chances are there are at least some fossil remains of the tool-makers preserved somewhere.”

> **“Hominins on these islands evolved in isolation into strange new species”**

HEALTH

Scientists publish findings from 25-year study of ‘super-agers’

The results could uncover new ways to delay or prevent dementia

After 25 years of research, scientists at Northwestern University, in the US, have discovered why some adults live well into their 80s and beyond with near-perfect cognition.

The memory of these ‘super-agers’, as the researchers call them, is as good as that of adults in their 50s and 60s.

Since 2000, scientists have studied 290 super-agers and autopsied 77 of their brains to understand what makes them so resistant to cognitive decline.

They discovered personality traits that are more common in super-agers compared to the general population. These individuals tend to be highly social and report having strong interpersonal relationships.

These personality differences are just the beginning, though. Dr Sandra Weintraub, one of the authors of the new research, said: “It’s really what we’ve found in their brains that’s been so earth-shattering for us.”

In some of the super-agers’ brains, the scientists found amyloid and tau proteins (known as plaques and tangles), which play key roles in Alzheimer’s disease. In others, they didn’t.

The key thing is: none of the brains showed signs of the damage usually associated with those proteins.

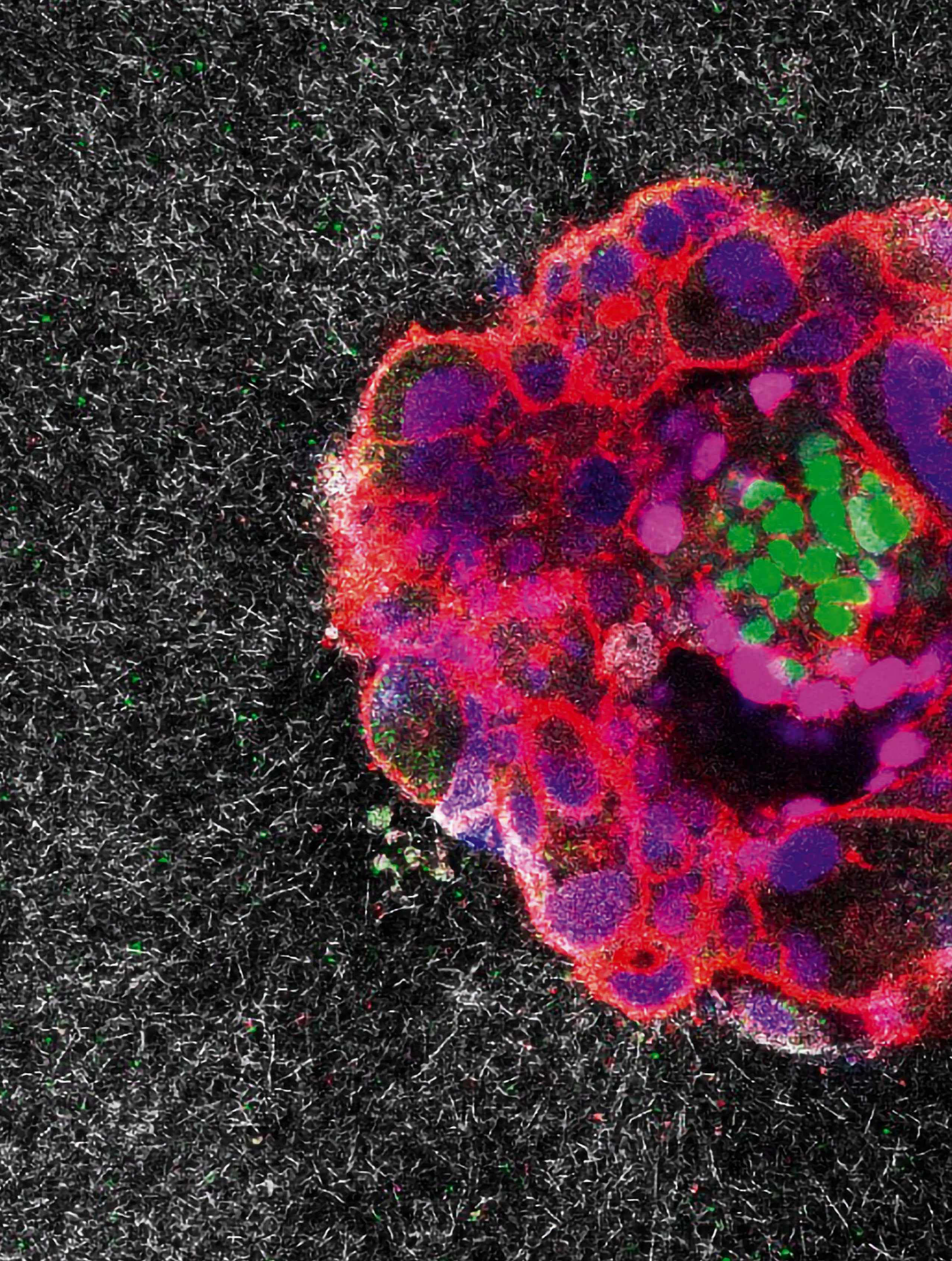
“What we realised is there are two mechanisms that lead someone to become a super-ager,” said Weintraub. “One is resistance: they don’t make the plaques and tangles. Two is resilience: they make them, but they don’t do anything to their brains.”

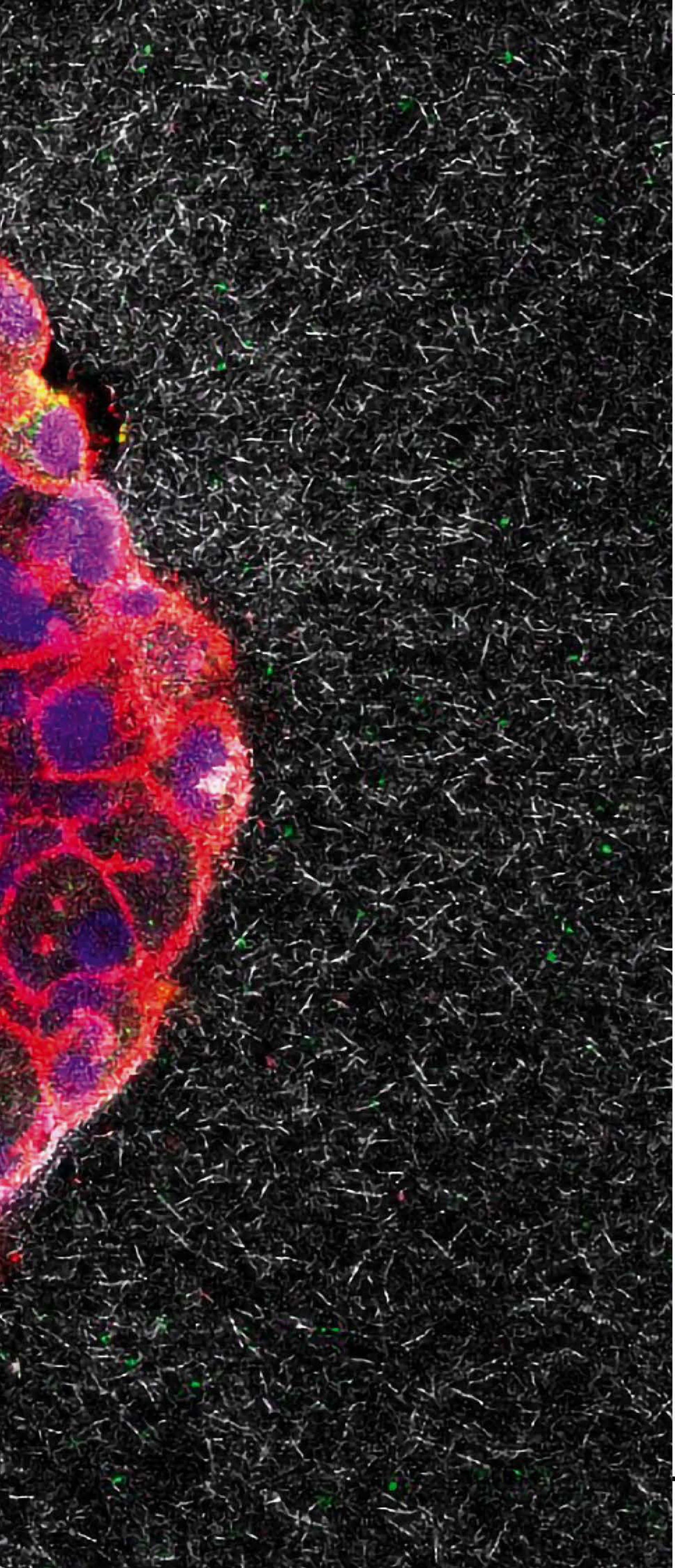
That wasn’t all. These super-agers also had a youthful brain structure. Older brains generally have thinner cortexes (the outer layer of the brain) than younger brains, but the super-agers’ cortexes hadn’t thinned.

In particular, they had very youthful thickness in their anterior cingulate cortex, which is a crucial region of the brain involved in decision-making, emotions and motivation.

The super-agers also had more spindle cells – neurons found in the cortex that play a role in social behaviour and emotional processing – compared to their peers.

“Our findings show that exceptional memory in old age is not only possible but is linked to a distinct neurobiological profile,” said Weintraub. “This opens the door to new interventions aimed at preserving brain health.”





MEDICINE

Groundbreaking footage captures hidden moment of human fertility

Observing the crucial step in human development could help improve fertility and IVF

This false-colour 3D image shows a human embryo, nine days after implanting into the uterus platform. Among the green dots in the centre, the embryo and its yolk sac are developing. The black space below the green dots is the proamniotic cavity into which the embryo will grow and develop

INSTITUTE FOR BIOENGINEERING OF CATALONIA

The first real-time footage and 3D images of a human embryo implanting into an artificial uterus have been captured. The remarkable feat, published in the journal *Science Advances*, offers an unprecedented view into one of the most critical steps in human development.

Implantation is the stage in early pregnancy when a fertilised egg, now a developing embryo, attaches itself to the lining of the uterus. This step allows the embryo to draw nutrients and oxygen from the mother, making it essential for a successful pregnancy.

To study the process, researchers built a platform that mimics the lining of a real uterus, consisting of a scaffold made of collagen and a mixture of proteins necessary for development. They then studied how both human and mouse embryos implant on the platform, revealing key differences between the species.

Unlike mouse embryos, which adhere to the surface of the uterus, human embryos (like the one seen here) penetrate the tissue completely before growing from the inside out.

Implantation failure in the uterus is one of the main contributors to infertility, accounting for 60 per cent of miscarriages. The researchers hope that a better understanding of the implantation process could help improve fertility outcomes, both in natural conception and in vitro fertilisation (IVF).

HEALTH

97% of autistic adults over 60 are undiagnosed

Their autism was missed during childhood, resulting in an 'overlooked' generation of autistics

Older people are much less likely to have their autism diagnosed, a major new review has found.

The research estimated that around 89 per cent of autistic people aged between 40 and 59 have never had the condition identified. For people over 60, that number jumps to 97 per cent.

The analysis brought together multiple studies on how autism impacts people later in life, finding that autistic elders experience higher rates of almost all physical and mental health problems, are less likely to have been employed and tend to report lower general wellbeing.

Older autistic people also struggled to receive medical care and form strong relationships, both of which are strongly associated with poor health outcomes.

"Many undiagnosed autistic people often won't have access to appropriate help and support to address issues like poor mental health," review lead Dr Gavin Stewart, told *BBC Science Focus*.

This lack of support also bars autistic people from receiving proper medical care, as several core autistic traits – such as different communication styles, sensory sensitivity and a need for routine – can make navigating modern health systems difficult.

The study aimed to address the fact that almost all autism research has been focused on children and young people. Only 0.4 per cent of studies have looked into the impact of autism on older adults.

Although autism is thought to affect around one in 100 people, the number of recorded diagnoses declines sharply in those over 40 years old.

"The high rates of underdiagnosis [for older people] mean that much of our research has systematically overlooked a large proportion of the autistic population, potentially skewing our understanding of how autistic people age, and leaving critical gaps in policy and services," said Stewart.

"Almost all autism research has been focused on children and young people"

ABOVE Heightened senses mean some autistic people struggle with loud and busy places, leading them to self-isolate

"A reason for this is that many autistic people who are older today are likely to have been overlooked as young children under the original narrow diagnostic criteria."

In the 21st century, most autistic people are typically diagnosed in early childhood – but the condition has only formally been included in medical diagnostic manuals since the 1960s.

Growing awareness among educators, medical professionals, families and the general public also means people are now more likely to identify the symptoms in children and adults alike.

GETTY IMAGES

2000T

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REALITY CHECK

THE SCIENCE BEHIND THE HEADLINES

REVIEW

Cortisol is actually good for you. Here's how to maintain a healthy level

Influencers are demonising a hormone that plays a star role in regulating your body

BBC
For more fact-checking news, visit the BBC's Verify website at **bit.ly/BBCVerify**

Feeling tired? Bloated? Having trouble sleeping? Your cortisol levels might be too high – or, at least, that's what social media would have you believe.

Cortisol is the latest chemical to fall under the spotlight as, in many health and wellness influencers' eyes, it's to blame for all manner of problems – problems that the correct combination of supplements can, of course, fix. But what exactly is cortisol? And why is it causing so much trouble?

Cortisol is commonly known as the stress hormone. When you sense a potential threat, the amygdala in your brain triggers the 'fight or flight' response: adrenaline and noradrenaline are released to prepare you to do battle or run away. This is what you feel when you're made to jump during a scary movie or are nervous before a big work presentation.

Most of the time, the stress doesn't last long – the scare is momentary, the presentation is only a few minutes – and your adrenaline levels return to normal shortly after it passes. Neuroscientists and psychologists call this acute stress and, in moderate amounts, it's actually good for us.

> "The stress response isn't cortisol's only role"

Cortisol comes into the equation when that stress is prolonged or feels unmanageable. In these cases, cortisol is released from the adrenal glands on top of your kidneys. It peaks after 15–20 minutes and, during that time, helps your body to continue responding to the threat by making sure energy is available and blood is flowing to the muscles, as well as keeping your brain alert.

But this doesn't happen every time we're afraid or stressed – far from it. "Getting a cortisol response from acute stress is actually quite difficult," says Prof Stafford Lightman, at the University of Bristol Medical School. "It's very easy to get an adrenaline response, but causing cortisol release is a challenge. It's whether you personally perceive something as being a severe enough threat."

But the stress response isn't cortisol's only role. It has other important functions as well, some of which are positive. For example, cortisol helps you get up in the morning: your cortisol levels rise before you wake. Without this increase preparing you for the day, it would be even harder to get out of bed.

Cortisol plays a huge range of roles, Lightman points out. "Cortisol is a signalling molecule – almost every tissue in your body has cortisol receptors: your muscles, your liver, your brain."

ABOVE Cortisol is made and released by the adrenal glands on top of your kidneys

OPPOSITE Cortisol seen under a light micrograph

SCIENCE PHOTO LIBRARY X2

When your organs and muscles receive signals from cortisol, it triggers them to carry out important functions that keep your body stable. For example, when organs such as your liver and pancreas detect cortisol, it helps them to maintain steady blood sugar levels and keep your blood pressure consistent. Cortisol can also trigger anti-inflammatory mechanisms in the body, helping to boost your immune system for short bursts.

"[Cortisol] does multiple things," Lightman says. "And it's kept very carefully under control by the body because so much depends on it. In fact, it's the only hormone you need for life – without cortisol, you would die."

PATTERNS MATTER

You certainly need some cortisol, then, but what if you're worried you have too much of it? An amount that, as the influencers are so keen to point out, could be causing you problems.

Determining that can be tricky, though, as your cortisol levels naturally fluctuate throughout the day (rising in the morning and falling in the evening). The trouble is that the at-home test kits used to measure your cortisol levels ask you to check them just once a day and claim this gives you an indication of whether they're generally 'high' or 'low'.

Lightman describes these tests as "complete rubbish" and points out that "the variation of normality at any one point in time is massive so you couldn't possibly tell whether someone's cortisol was high or low. 20 minutes later, it might be completely different."

To really know what's going on, you would have to measure your cortisol levels many times, over many days – this is how doctors diagnose diseases linked to changes in cortisol release.

"Far from being the bad guy, cortisol is a hormone that's vital for our bodies and brains"

To complicate matters further, cortisol is also released in bursts, about every hour or so. This pattern changes gene activity and is vital for a whole range of functions.

One study investigating this recruited healthy volunteers, blocked their natural cortisol and substituted it with matching doses that mimicked either a daily (circadian) rhythm without pulses, or a circadian rhythm with pulses (similar to a natural release pattern).

The participants on the non-pulsed protocol scored worse on working memory tasks and reported poor sleep. Those on the pulsed protocol, however, were less able to accurately identify facial expressions, which is conversely linked to better mental wellbeing. The results suggest that it's not necessarily the amount of cortisol in your system that affects your ability to function, but the pattern with which it's released.

Studies on mice also suggest that we're able to learn new skills better while our cortisol levels are higher, as neuron connections form more easily. But we need cortisol levels to dip for these skills to be stored long-term in the brain.

But even if you could track cortisol over a whole day, this still wouldn't say much about your health. "You would first have to define normality for that particular person," says Lightman, "and then show that their pattern for the day fell outside the normal range. Nobody has done that. All these wellness people tell you is that your pattern is 'dysregulated', but that's complete rubbish."

BELOW Long-term stress doesn't necessarily mean your cortisol level is high

DON'T PANIC

Scientists agree that chronic stress is bad for your health and that managing it can make our lives a little better. But, Lightman says, we shouldn't always jump to blame cortisol. "Health problems can develop if you experience long-term stress – a divorce, losing your job, something that wakes you up in the night worrying. That doesn't mean cortisol is causing it."

Tackling the source of our stress is the best remedy, rather than resorting to supplements in a bid to reduce cortisol levels, but this isn't always an option. Luckily, we can manage our stress levels in other ways. A 2019 study, for example, found that older people given dance training for three months showed a reduction in their peak cortisol and dancing has also been shown to reduce feelings of stress.

Hugs can also be a great way to deal with short-term stress. One study found that when students received more than their usual number of hugs in a day, their morning cortisol spike was lower the day after. A walk in the woods can also be beneficial, reducing cortisol levels by 53 per cent in one study.

Far from being the bad guy, cortisol is a hormone that's vital for our bodies and brains, and for the vast majority of us, it's simply not something worth worrying about.

We're far better off focusing on the basics of healthy living (diet, exercise and sleep) and stepping away from the influencers trying to sell us the latest fad. Especially when there are moments of joy to be found by engaging with the real world instead.

by **GINNY SMITH**
Ginny is a neuroscience writer and author of Overloaded: How Every Aspect of your Life is Influenced by your Brain Chemicals.

GETTY IMAGES X2

ABOVE
Supplements are popular with people looking to perform better in sports at all levels

ANALYSIS

What doctors really want you to know about sports supplements

Athletic enhancers are big business. But it's not always clear which ones actually work or what might be in them

Tart cherry juice seemed to be the drink of choice at the Tour de France this summer. Riders taking on the race, which took place over three weeks in July, were spotted gulping down the supplement at the finish each day.

Elsewhere, footballers and tennis players have been seen swigging pickle juice, while athletes in other events have been consuming baking soda gels. These are just the latest sports supplements to gain widespread attention – there are many more exotic options already available. But what are they actually doing for athletes?

WHAT SUPPLEMENTS ACTUALLY WORK?

Supplements are widely available and used by athletes at all levels. They can be consumed for several different reasons. For example, professional athletes may take them to obtain a high dose of a particular nutrient in concentrated form and help meet the high-energy needs of an endurance event. Creatine, for instance.

Creatine is a compound produced in the body and found in protein-rich foods such as meat. It can act as a quick source of energy for muscles, and some research recommends that people who exercise consume up to 20g of creatine per day to maintain their body's stores of the compound. But doing so would mean eating 4kg (8lbs) of steak.

"[Creatine] needs to be used as a supplement in that regard because it would be very uncomfortable to eat that amount of meat," says Dr Stephen Bailey, a leading expert on exercise physiology from Loughborough University in the UK.

Supplements also have the potential to enhance performance. Bailey thinks that athletes should prioritise eating a nutrient-rich diet, fine-tuning how much water they drink and perfecting their training to obtain the best

results. But supplements could provide an additional boost once those are all taken care of.

"In elite sport, the margins between success and failure are very small," he says. "So, if you've done everything else well and you're looking for that very small incremental improvement, then [supplements] might be able to give you a meaningful performance outcome."

Ketone drinks, for example, have become popular among elite endurance athletes looking to gain a competitive advantage. When the body turns fat into energy during prolonged exercise, molecules called ketones are produced that can be used as a source of fuel for muscles and the brain. They're an alternative to glucose, the body's main source of energy.

"Ketones are there to top up glucose levels," says Prof Kieran Clarke, a biochemist at the University of Oxford.

Clarke and her colleagues invented a ketone drink that was shown to help professional cyclists ride 400m (1,300ft) further over half an hour, on average, compared to those who consumed energy drinks containing carbohydrates or fat.

Ketones can also provide a cognitive boost, which Clarke thinks is more significant. At the Tour de France, for example, riders may start to lose their ability to think strategically when their glucose levels are low at the end of the day's stage.

"That's where [ketone drinks] really help," says Clarke.

Sports supplements can also help with recovery after a competition. It's likely to be the main benefit of tart cherry juice since it has anti-inflammatory properties. "It's a fairly successful way to try and manage inflammation post-exercise," says Bailey. "That might then lower soreness."

THE PROBLEMS

The big problem with sports supplements, however, is identifying which ones are effective. The market is flooded with them and while all claim to have benefits, many haven't been rigorously tested.

"There's a lot of money in the dietary supplement business," says Floris Wardenaar, an associate professor in sports nutrition at Arizona State University in the US. "It's really easy to start your own supplement business: basically anyone, without any knowledge, can create something."

Even in cases where a supplement has been studied, it might have been tested on muscle cells in the lab, but not when ingested by humans. In a consensus statement issued by the International Olympic Committee (IOC)

ABOVE Riders taking on the Tour de France are known to have consumed sports supplements, such as ketones and tart cherry juice

RIGHT The World Anti-Doping Agency (WADA) produces an annual list of substances banned for use in sports, some of which have turned up in supplements

> "The market is flooded with supplements and while all claim to have benefits, many haven't been rigorously tested"

GETTY IMAGES, ALAMY

in 2018, just five supplements were backed for athletic use: caffeine, creatine, nitrate, beta alanine and sodium bicarbonate. They were the only supplements supported by significant evidence showing performance improvements in specific scenarios.

Besides the concerns over the efficacy of sports supplements, contamination is also an issue. In the UK, supplements are regulated as food, but it can still be hard to control what's in them (in the US, they're not regulated as tightly).

Nevertheless, it's not impossible for impurities to be introduced during the manufacturing process, and analyses of supplements have found banned substances, such as anabolic steroids, in 14–15 per cent of samples tested.

Athletes typically take several supplements, many of which may be contaminated, making the issue even more complex. Wardenaar says that small amounts of banned substances in different products could add up and, in theory, cause a positive doping test. A result that could see the athlete banned from competition.

"Going to a third-party testing organisation is the route to go to make sure a supplement has the substances [an athlete] is looking for, as listed on the label," he says.

wada
wada
Athletes & Support Personnel
The Prohibited List
Explore the list
Read the FAQ

THE CHANGING LANDSCAPE

Whether certain substances in sports supplements should be prohibited can also be a grey area. The World Anti-Doping Agency (WADA), an international independent agency that aims to prevent doping in sports, bans substances that satisfy two out of the three following criteria: if they enhance sports performance; if they represent an actual health risk to an athlete; and if they violate the spirit of sport.

The list is reviewed annually to address substances that have come to prominence and may have the potential to be misused.

Caffeine, for example, used to be on WADA's prohibited list. But in 2004, its use was permitted again for a number of reasons, including that the performance boost was considered to be minor and because it's so widely present in foods and drinks that it's hard to control.

What's more, determining how a supplement might affect an athlete isn't always straightforward since the effect can vary between individuals. Some people will be set for the day after one cup of coffee, for example; others will need two or three.

Complicating matters further, according to Bailey, is the fact that the personalisation of supplements is becoming more widespread. Genetic testing technologies are being used to examine how an athlete's genes may affect their response to nutrients or other food components, for example.

Gender is also influencing supplement recommendations now. Different amounts of carbohydrates and protein are now recommended for male and female athletes, for example. There are also questions around whether women might need different supplements at different times in their menstrual cycle or whether the effect of the contraceptive pill should be considered.

As new formulations of different supplements continue to hit the market, athletes may also be able to get a better boost. Bailey says that sodium bicarbonate supplements (baking soda, basically) have been a popular choice to neutralise the fatigue-causing lactic acid produced during high-intensity exercise. However, they can also cause stomach problems such as nausea and diarrhoea. Many companies have created hydrogels that release baking soda further along the gastrointestinal tract to alleviate this.

"There are constantly new approaches in terms of food technology," says Bailey. "Sodium bicarbonate is very topical at the moment in elite cycling, so more work needs to be done to help us understand that scenario." SF

by **SANDRINE CEURSTEMONT**

Sandrine is a freelance science journalist, whose work has appeared in BBC Future, National Geographic *and others.*

INNOVATIONS

PREPARE YOURSELF FOR TOMORROW

COMMENT

SIZE MATTERS

Switching to electric vehicles is making our roads cleaner, but no less congested. There's a simple solution to this problem, but no one wants to hear it

by QUENTIN WILLSON

Imagine the vision: silent streets and sweeter air. Slippery-shaped two- and three-seaters cleaving along dedicated routes, batteries charged by induction coils embedded in the road. Featherweight, efficient, urban mobility solutions. Like those drawings of the futuristic cities in the comics I used to pore over as a kid – no smog, jams or parking wars. A fiction soon to become a reality, surely? Well, actually, no.

We've been able to buy small, compact electric vehicles (EVs) for quite a while. The Fiat 500e, Ora 03, Renault Twizy, Smart ForTwo Electric, Citroën Ami, the Microlino (left) – and the car that started the EV microcar revolution – the notorious G-Wiz. They've been available, reliable and practical for years. Smaller, lighter, easier to park and own, and potentially with longer battery range – all solid benefits of micro EVs that you think would have galvanised interest from early adopters. But sales have been glacial.

The fact is, most consumers – even those who go electric – don't want tiny EVs. They want muscly SUVs.

SMALLER EMISSIONS, BIGGER CARS

I was debating SUVs with a nice man from the Clean Cities Campaign on *BBC Breakfast* recently. We agreed that all those cliff-fronted, combustion-engined Defenders, Discoveries and G Wagons have no place in British towns and cities – and for very good reasons. Pollution, pedestrian safety and size are just a few.

But, and here's the unpalatable, depressing and inescapable truth: trying to legislate against the SUV would be like trying to draw up laws against the sea. Because in 2024, a staggering 62 per cent of all new cars sold in Britain were SUVs. An increase of 23 per cent since 2023.

Some of those SUVs sold will be electric – Tesla, Skoda, Audi, Kia, Volvo, Polestar, Mercedes, BMW and Hyundai all do great battery-only SUVs. But they're still too portly for our crowded urban roads and parking spaces designed in the 1960s for skinny cars and vans.

EV SUV exhaust emissions may be zero, but they still use the traditional 'two-box' architecture of spaces for people and luggage. And since the 1990s, cars have been expanding by at least 1cm (0.3in) every year. This bloating phenomenon even has a name: autobesity.

BELOW The minimum specified width for an on-street parking space in a British city is 180cm (70in). Many SUVs on sale now are wider than that

> "What we need to shift consumer sentiment towards smaller, city-friendly EVs, is government policy"

T&E, a non-governmental organisation advocating for clean transport and energy, reckons that over half the cars sold in 2024 were too wide for the minimum specified on-street city parking space of 180cm (70in), with some SUVs expanding to over 200cm (over 78in).

Some of those extra centimetres are due to safety kit like passenger airbags and side-impact beams, as well as conveniences like air conditioning and all-wheel drive. But people are also lugging around more bikes, dogs and stuff. For most modern families, the SUV has become an essential tool.

DRIVEN TO DOWNSIZE

I believe we need to encourage the transition to electric cars first, before we expect consumers to downsize. As I write, 26 per cent of all new cars sold are EVs, that's one in four. And if you include hybrids, one in three new cars now comes with a plug.

We may not make the UK government's 80 per cent Zero Emission Vehicle Mandate target by 2030, but we're making decent progress with Britain leading Europe both in EV sales and thought leadership. But what we need to shift consumer sentiment and behaviour towards smaller, city-friendly EVs, is government policy.

Simple, low-cost incentives would help stimulate a new market. Things like free use of bus lanes, free nationwide parking, no tax on the purchase price, subsidised social leasing schemes, reduced insurance premiums and free public charging. Imagine an electric three-seater you could lease for less than £50 a month, park anywhere for free, drive down bus lanes and charge up for nothing. If you want to kick-start a new industry (and these pint-sized EVs should be built in Britain), intelligent, far-sighted government policy is the place to start.

But don't hold your breath. The Mayor of London is threatening to cancel the Clean Vehicle Discount for EVs in the Congestion Zone from December this year and too few politicians and civil servants tell us that they own and drive electric cars. Which is a shame, because the small electric car offers a real opportunity to reduce traffic densities and improve urban air quality.

Don't expect people to jump on a dirty, over-priced and unreliable public transport system. Instead, offer us the incentivised micro-EV as a new personal mobility solution. Perhaps we won't even have to own or lease them at all, but use them by the hour like the fleets of rental bikes now found in so many cities.

As London sinks into its daily routine of gridlock – the unintended consequence of years of poor transport policy – the electric microcar seems such an obvious solution to help reduce those jams and shift driver behaviour towards smaller, cleaner alternatives. Provide enough reasons and incentives for those behavioural changes and we could create a new genre of personal transport along with a whole new industry.

Backed by government, built in Britain, powered by free, renewable electricity and costing buttons to own and drive – this, surely, is what part of our electrified future should look like?

But we're being dictated to by the car industry, gorged on profits from SUVs. We need to break this cycle of SUV dependence and use the energy transition to change what we choose to drive in our towns and cities.

Giving up the motor car was always going to be tough. We've started by making it zero emission. Now we need to make it smaller. But for that, we need political leadership – a virtue sadly lacking right now.

by **QUENTIN WILLSON**

Quentin is an award-winning motoring journalist and transport campaigner. He presented BBC Two's Top Gear *for a decade along with many other motoring and consumer shows.*

MICROLINO, GETTY IMAGES

5 of the Best Electric toothbrushes

Whether you're seeking professional precision or just a thorough clean, these brushes use science and dentist-backed design to keep cavities at bay

by RHIAN MORGAN

BEST VALUE
Oral-B
iO

Oral-B iO2

Toothbrushes in Oral-B's iO range feature a dual-action motion. As well as rotating back and forth, the brush head has an oscillating linear motion, allowing it to probe into the gaps between your teeth and clean more thoroughly. Studies show that Oral-B's oscillating-rotating technology removes plaque and reduces gingivitis more effectively than manual brushes, with most people noticing improvements in as little as a week.

The iO2 brush is intended as an 'introductory' device to make switching from a manual to an electric brush easy. So, while it carries the oscillating-rotating technology, it remains simple to use. It has just one button, which lets you switch between the brush's three modes (daily, gentle and extra gentle), a built-in timer that signals when to switch brushing areas and an automatic pressure sensor that alerts you to when you're brushing too hard.

The iO2 is a great choice for children, or anyone who struggles with cleaning their teeth –especially if they're keen to make the switch to electric.

£100, shop.oralb.co.uk

How to clean your teeth like a dentist

"The main thing to figure out when buying an electric toothbrush is what sort of brushing experience you want," says dentist Dr Anita Selvarangan, of Sevenoaks Dental & Wellbeing. "Sonic is preferable to oscillating if you're more sensitive to vibrations. After that, the features I'd look for are things like pressure sensors, timers and good battery life." But oral hygiene isn't all about the toothbrush – good technique, diet and toothpaste are important, too. Here's what to look out for, according to Dr Selvarangan.

It's not just about the brushing

"Spit out your toothpaste after brushing, but don't rinse with water – this is more effective than using a mouthwash after brushing. And remember: brushing alone can miss up to 40 per cent of teeth surfaces, so it's just as important to use dental floss or tape and interdental brushes. I recommend applying toothpaste to these as well."

Sugar is the enemy

"To lower your risk of tooth decay, only consume sugar at mealtimes. Between meals, stick to drinking water and eating savoury snacks. Remember: natural sugars still count, so snacking on fruit throughout the day can lead to an increased risk of cavities. It doesn't matter how good your toothbrush is, if you consume sugar more than three times a day, your risk of decay will be much higher."

Should I use fluoride?

"Some people prefer to use a non-fluoride toothpaste, and there's growing research on whether hydroxyapatite toothpastes (a non-toxic alternative) are also effective in preventing tooth decay. But this is still a relatively new area. For most people, using a fluoride toothpaste is highly beneficial. I use a fluoride and sodium lauryl sulfate (SLS)-free toothpaste, but I also maintain a natural diet free from refined sugar."

BEST FOR TECH
0 1:45

Oral-B iO10

If you want high-tech oral hygiene and you're not tied to a budget, you might want to consider the iO10 – the brush at the opposite end of Oral-B's iO range to the iO2.

Billed as "the world's smartest toothbrush", the iO10 is packed full of features and even provides personalised feedback via its display and charging station (think of it like having a dentist watching over you and offering tips as you brush). It also has seven brushing modes to choose from – easy clean, sensitive, whitening, gum care, intense, super sensitive and tongue clean – to help you tailor your brushing to your mouth's specific needs.

The iO10 delivers the sort of deep clean that feels like you've just visited the hygienist, but it's not cheap. That said, it can be found heavily discounted online, but even at half the recommended retail price, it's still a lot to spend on a toothbrush.
£800, shop.oralb.co.uk

Spotlight Oral Care Sonic Pro

Spotlight Oral Care's Sonic Pro toothbrush is a good shout if you're not looking to break the bank, as it strikes the sweet spot between performance, price and user satisfaction. Created by Irish dentist sisters Drs Lisa and Vanessa Creaven, the Sonic Pro is designed to offer professional oral care and punches well above its weight in terms of quality

Its sonic technology relies on a brush head that vibrates from side to side at a range of frequencies depending on your chosen mode. There are four to choose from: gentle, clean, white and polish, and their head speeds range from 30,000 revolutions per minute up to 50,000.

It also has a pressure sensor to ensure it stays gentle on gums. A single charge lasts an incredible 70 days, so the familiar whine of the battery running out mid-brush should be a thing of the past. It does tend to be a bit noisier than some of the more expensive brushes tested here, though.
£149.95, uk.spotlightoralcare.com

BEST ALL-ROUNDER

Philips Sonicare 4100

In a market flooded with high-tech dental gadgets promising dazzling smiles, Philips is a consistently proven performer. It remains the number-one brand for professionally recommended sonic toothbrushes worldwide and its 4100 is a solid performer that proves simplicity and smart design still have a place.

Unlike more expensive models that boast five or more brushing modes, the 4100 keeps things refreshingly simple with just two: clean and sensitive. It does have some smart features, though: a pressure sensor, timers to ensure a thorough clean and a light that lets you know when the head needs replacing. While it lacks Bluetooth connectivity or app integration, most people won't miss them, especially when the core cleaning performance is this strong.

The battery life is solid, lasting up to two weeks on a single charge, and the slim, lightweight design makes it ideal for travel.
£109.99, philips.co.uk

Curaprox Hydrosonic Pro

BEST FOR PRECISION

Looking for an electric toothbrush with a lighter touch? The Hydrosonic Pro from Swiss dental company Curaprox could be the brush for you. It's been designed to polish your pearly whites with a caress that's more gentle than a typical electric toothbrush, making it ideal for people with braces, dental implants or sensitive gums.

The secret to its delicate demeanour is a head that makes 84,000 movements per minute – many more than most other toothbrushes, and fast enough to be practically imperceptible. Touch its head to your teeth and it comfortably, but thoroughly, cleans them without the skull-rattling sensation that other brushes can inflict.

Seven cleaning modes and three specialised brush heads provide enough combinations to ensure every spot in your mouth gets reached and scrubbed.
£190, curaprox.co.uk

EDITOR'S PICKS...

This month's smartest tech

...LISTEN UP

This is perhaps one of the most profound set of updates I've seen a device get. Apple's AirPods Pro 3 now provide in-ear, real-time translation for English, French, Spanish, German and Portuguese.

The AirPods will translate, on the fly, what someone is saying to you in another language. Siri, Apple's virtual assistant, acts an interpreter, converting what the AirPods hear into the language of your choice. The results also appear as text on the screen of your phone at the same time.

Live translation itself isn't new. Translation apps can listen to someone speak and convert it into your language of choice, in text form. But Apple's execution here, throwing together several AI tools to provide an instant audio interpretation to your ears, completely dissolves language barriers – awkward pauses and all. If only Douglas Adams were alive to see it – a real, live Babel fish. Of course, to take part in a full conversation, the two of you will both need AirPods, but they're already fairly ubiquitous: how many people do you see with one AirPod hanging out their ear? Plus, this update will work with previous models too: the AirPod Pro 2nd generation and AirPods 4. You'll just need an iPhone 15 (or newer) with the latest operating system installed to get the translations working.

That's not the only meaningful addition to the AirPods' feature set. Back in April, Apple turned existing AirPod Pro 2s into "clinical-grade" hearing aids – and it's a key feature in the AirPod Pro 3, which invites you to take a hearing test when you first connect them to your phone. It's hard to understate how vital this could be: the numbers are staggering. In the UK, government-provided figures estimate there's around 7m people who would benefit from a hearing aid, but don't currently use one. In the US, that number is thought to be around 30m.

The AirPods will boost the frequencies you struggle to hear and even adjust your media to better suit your hearing profile, if you so choose. They're not intended to replace medical-grade hearing aids, but simply fill a gap, since even those who do discover they need a hearing aid can spend months, even years, waiting for one.

Meanwhile, the AirPods themselves have had a redesign. Most notably, the ear tips are now capped with foam, which means they're far less lightly to fall out (I can vouch for this) and are better at noise-cancelling. Apple has added heart rate sensors to the shell, too, so you can use them to track your health. Battery life has also been improved, giving you eight hours of continual listening with noise cancellation before they need to go back to the case for a charge.

AirPods Pro 3
apple.com, £219

↓ ...PARTY TIME!

While I'm not totally convinced that we need to see cassette tapes make a comeback, this boombox had me reaching for my wallet. For those of you rejoicing in physical media's second coming, this stereo system houses a tape deck, a CD player and an AM/FM tuner. Sadly, since most of the information about it is in Japanese, I can't confirm whether you can agonisingly record songs from the radio onto a tape. What I do know is that this boombox also works as a Bluetooth speaker (yes, it's powered by actual removable batteries). It'll even play MP3s from a memory card, too. In that context – as a wireless speaker – this design offers oodles of personality compared to the anonymous sea of Bluetooth speakers out there. Plus, if you plug a microphone in, it works as a karaoke machine, too!

Zutomayo Orion SCR-B9(Z)
zutomayo.net, ¥42,000 (£210)

← ...WAFER THIN

5.6mm (or just 0.2in) thick. That's how thin the new iPhone Air is, which, when laid flat, means it's about as tall as two £1 coins stacked on top of one another. This form factor alone makes it the most remarkable iPhone in years. In your hands, I dare say it's a beautiful thing, but sleekness like this comes with compromise. You'll probably barely notice the difference in processing power (unless you're a power user, editing videos on the fly), but you might notice the shorter battery life and less powerful camera compared to the iPhone 17, which is around £200 cheaper. So, if you're glued to your phone, go for the 17 or 17 pro, otherwise, revel in the beauty of what might be the most desirable phone out there.

iPhone Air
apple.com, £999

↓ ...GIVE US A WAVE

There's a new type of biometric sensor in town and it can identify you from the pattern of veins in your palm. This new smart lock uses the tech to protect your home and it makes a lot of sense. Doorbell cameras often sit at a tricky angle to employ facial recognition and fingerprint readers can get dirty and greasy. Instead, waving at your door seems like a reasonable solution. This device can remember multiple palm profiles and includes a keypad if you need to give someone entry at short notice – or the sensor stops working.

TCL D2 Pro Palm Vein Smart Lock
tcl.com, £TBC

TCL
1 2 3
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↓ ...LAWNMOWER BOY

The Virtual Boy is making a comeback. Granted, many might not know it was ever here, let alone gone, but Nintendo's lovably anachronistic take on virtual reality is returning for the Switch 1 and 2. You just slot your Switch's screen into the headset case (a bit like slotting your phone into Google's Cardboard headset – remember those?) and then you can play all the weird, red-and-black, stereoscopic-3D classics you desire, like *Teleroboxer* and *Jack Bros*. Don't remember them? No, me neither. But Nintendo is the master of retro fun, so they should be a laugh. If you don't want to spend the full £66.99, there's a cardboard model for £16.99 – though without a strap, you'll have to leave the controllers attached to your Switch so you can hold everything against your face while you play.

Virtual Boy for Nintendo Switch
nintendo.co.uk, £66.99

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WELCOME TO THE DREAM WORLD

New technology aims to help you induce a lucid dream at will, enabling you to enter a state of consciousness where anything is possible. Dare you close your eyes?

by IAN TAYLOR

Imagine waking up to find that you're not awake at all. Your body is asleep, but your mind is running free in a dream where everything feels vivid and real and – because you know you're dreaming – you can control what happens.

In this hybrid state of consciousness, known as lucid dreaming, you can go where you want, see who you please and do the impossible. And you can feel the sensations of it, too: the wind in your hair as you fly over a city; the sun on your skin as you land on a desert island of your own design. You can sit down on the sand and smile, knowing you can do it all again tomorrow night at the simple touch of a button.

ILLUSTRATION: ANDY POTTS

If all that sounds like… well, a dream, it's one that might come true in the near future. It's certainly what a group of researchers and technologists are working towards. They're building high-tech sleep masks and other trippy brain-interface technology in the hopes of transforming lucid dreaming from a niche interest into something that all of us can do.

For the majority of people who can do it, lucid dreaming is something that happens by accident or after months, possibly years, of practice. Dream tech companies like REMspace and Prophetic are exploring ways to induce lucid dreaming at will.

Most methods of doing this involve stimulating the prefrontal cortex. That's the region of the brain found to be active during lucid dreaming and which is associated with higher-level conscious thought in the waking world. Most dream tech achieves this using some kind of signal, from simple sounds and alerts, to more complex methods using electricity, ultrasound or magnets to stimulate areas of the brain.

"Maybe it looks like sci-fi right now, but believe me, in a few years it won't," says Michael Raduga, CEO and founder of REMSpace. "I'm convinced that this technology is going to be the next big thing after artificial intelligence (AI) – and it will change humanity as much as AI because it'll literally provide us with an alternative reality."

DREAMS AND REALITY

Hearing all this, it's difficult not to think of the Christopher Nolan movie *Inception*, where the protagonists enter other people's dreams to steal information and generally look cool while they're doing it. But lucid dreaming isn't a Hollywood fantasy. It's been known about for centuries. Around half of all people are thought to have experienced the sensation of realising they're in a dream, but few people do it often and fewer still with any real intention.

Among history's dreamwalkers, however, are some of humanity's brightest minds. The physicist Richard Feynman reportedly used it to explore his ideas.

> "IN THIS HYBRID STATE OF CONSCIOUSNESS, YOU CAN GO WHERE YOU WANT, SEE WHO YOU PLEASE AND DO THE IMPOSSIBLE"

> “STUDIES HAVE SHOWN THAT WHEN PEOPLE PRACTISE A SIMPLE MOTOR SKILL IN A LUCID DREAM, IT MAKES THEM BETTER AT PERFORMING THAT SKILL IN REAL LIFE”

So did the inventor Nikola Tesla and the mathematician Srinivasa Ramanujan. Stephen King dabbles when working on his macabre stories, as did the artist Salvador Dalí. Nolan, too, based *Inception* on his own experiences with lucid dreams.

It’s also been the subject of intriguing research. Studies have shown that when people practise a simple motor skill in a lucid dream, it makes them better at performing that skill in real life. Researchers believe it could help everybody from sportspeople to recovering stroke patients.

Brain scans of people performing this kind of dream practice, show activation of the motor cortex – the area of the brain that’s active when someone performs that same skill physically while they’re awake. The implication is that the brain processes the lucid dream as though it were real.

Other work has looked at the therapeutic possibilities of lucid dreaming. Early research shows potential for treating nightmare disorders, insomnia, depression or post-traumatic stress disorder (PTSD). A pilot study in 2021 found that when insomniacs were taught lucid dreaming, most experienced significant improvements in their symptoms and sleep quality. In another study, 85 per cent of PTSD patients experienced a decrease in symptoms after taking part in a lucid dreaming workshop.

In both cases, the results stemmed from participants being able to enter distressing dreams and consciously rewrite the narrative.

TALKING IN YOUR SLEEP

More recently, researchers have found ways for lucid dreamers to communicate with the waking world – and even other lucid dreamers. Last year, Raduga’s company reported that two participants exchanged a basic form of communication while dreaming.

Their brain waves and other sleep data were tracked remotely. When a server detected that one participant had entered rapid eye movement (REM) sleep – the phase of sleep when lucid dreaming is most likely – it sent them a randomly generated word in a language developed for lucid dreaming called Remmyo. It’s based on the movement of facial muscles. The participant repeated the word in their dream using the same facial muscles and the response was recorded and sent to another person also having a lucid dream. When that person woke up, they were able to report the same word.

Researchers at Northwestern University in Illinois have also found that people in a lucid dream can communicate with the people monitoring them, without waking up. Dreamers were able to respond to yes-or-no questions and even solve simple maths problems using eye movements or sniff signals, measured via a small tube under their nose.

“These are small signals, not full sentences, but it shows people are capable of responding in dreams in real time and using their working memory,” says study author Prof Ken Paller. “There’s a team in Germany, however, that’s keen on having people use their eye movements to look at a virtual keyboard in their dream and spell out things with their eyes.”

DREAM TECH

To help people achieve lucidity in their dreams, Paller uses a technique called Targeted Lucidity Reactivation (TLR). This combines pre-sleep training, which teaches you to be aware of your surroundings and emotional state in a dream, with sensory cues like sounds that repeat before and during sleep. In one study, Paller’s team showed that TLR could work with a simple smartphone app: people who used it more than doubled the number of lucid dreams they had in a week.

It’s a low-tech way of inducing lucid dreams, and one that also works in the products Raduga has developed at REMspace. The company’s app and sleep mask, both called LucidMe, send signals during sleep in the form of sounds, lights and vibrations. LucidMe also features sleep tracking and dream journaling. Raduga says this technology can help people increase the volume of their lucid dreams,

ILLUSTRATION: ANDY POTTS

but that it still requires a lot of effort on the part of the dreamer.

"It can be a little bit frustrating; you have to invest a lot of time to experience it," he says. "And sometimes it doesn't work."

The next generation of the sleep mask will make it much easier to lucid dream, Raduga says, but he isn't ready to reveal details yet. Ultimately, he believes technology will give us the ability to hack our dreams at will – and he's already gone to extreme lengths to try it. In 2023, Raduga performed neurosurgery on himself, drilling a hole into his skull to insert electrodes in his brain.

He trained himself for the surgery by watching videos on YouTube and practising on sheep heads. Once he felt confident enough to go ahead, he set up a complex array of mirrors and screens to perform the four-hour procedure.

He was in Kazakhstan at the time, after being forced to leave his research lab in Russia when the war in Ukraine began.

"I was desperate," he admits. "I lost all my resources, lost everything in my life."

Obviously, this is not something anyone should try at home, as the consequences could be fatal. As for Raduga, he was hospitalised due to loss of blood, but the electrodes he'd inserted into his head worked, for a few weeks (they were removed – not by him – about a month later).

"We found that we could send hundreds of signals into my dream world without waking me up," he says. "So it means that if we develop a technology that sends signals into the dream world directly, we can wake up people in their dreams directly, without sounds, lights and so on.

"That crazy experiment has saved us years. Because now we know what to do."

ILLUSTRATION: ANDY POTTS

THE NEED FOR CAUTION

Raduga has a LucidMe app and mask on the market now, but is already working on more advanced neuromodulation technology. He envisions a future where a dreamer's brain is stimulated easily and painlessly by electricity, magnetic fields or ultrasound.

It's tempting to dismiss Raduga as a reckless maverick – a dreamer, you might say – but he's not the only one. Neuromodulation is a growing research field with scientists investigating its use as a potential therapy for chronic pain, epilepsy, psychiatric conditions and more.

For lucid dreaming specifically, the datasets are small and, because it doesn't happen every night, the results are often patchy. Studies looking at different types of electrical stimulation, for example, have shown inconclusive results.

There are also questions about how quickly this technology should make its way into the mainstream. Regulatory bodies can't keep up with the pace at which neuromodulation is advancing and it's raising questions around safety and accuracy. Our understanding of the underlying neuroscience of lucid dreams is still developing, Paller says. But even if we're targeting the right areas of the brain, can we be sure we're always hitting them?

"If you're doing electrical stimulation, for example, the electricity is flowing all over your head, inside your brain and out," Paller says. "It's really small currents, and not oscillating in a way that would produce an epileptic seizure or something, but there are these small risks."

There are also rare cases of people having bad experiences while lucid dreaming. "Some people have lucid nightmares that they can't wake themselves up from," Paller says. "That's very frightening because then you're stuck in it."

> "REGULATORY BODIES CAN'T KEEP UP WITH THE PACE AT WHICH NEUROMODULATION IS ADVANCING AND IT'S RAISING QUESTIONS AROUND SAFETY AND ACCURACY"

Researchers have warned that lucid dreaming is unsuitable for people with schizophrenia or other psychotic disorders, because it can exacerbate their symptoms. "If someone has dissociative tendencies [which can compromise their perception of time, their memory or their identity] in their waking state, it's maybe not best for them to do it," Paller says.

He believes that while some of the start-ups in this field are more willing than he is to make claims about the technology, he's still glad they're doing the work. That's because it will ultimately speed up our understanding of lucid dreams and their potential. "As a neuroscientist, there's a lot we can learn through these other methods."

One of those companies is Prophetic, a New York-based start-up that's working on a headband designed to increase lucid dreaming. Called the Halo, you'd wear the device to

THE DREAMERS

LUCID DREAMING CURED MY SLEEP PARALYSIS

John Mahood, designer

"I used to get sleep paralysis in my late 20s. I couldn't speak or move and because you can't process time properly in a dream, it felt like I was there for ages. I spoke to a neurosurgeon I know, who told me lucid dreaming might help. It took practice, but I found that if I read about lucid dreaming before going to bed, I was more likely to have one. I found I could sort of throw myself out of my body, so I'd go downstairs and sit in the living room instead of feeling trapped in my own body."

I TEACH PEOPLE HOW TO LUCID DREAM

Jade Shaw, coach

"Lucid dreams are a kind of platform for having an out-of-body experience and I help people do that. It can give you a decreased fear of death, make you more empathic. It can be quite transformative for people – deeper than therapy, deeper than hypnotherapy – because you're doing that work in the unconscious mind. The results can be similar to doing psychedelics and impact people's belief systems. It can also just be fun: the best cake I ever ate was one I had in a lucid dream."

I USE LUCID DREAMS AS A CREATIVE TOOL

Ben J Henry, author

"My lucid dreams started by accident while I was at university, but now I use them creatively. As a writer, it's really useful for meeting the characters in my stories. For instance, I had a character who was an artist and got them to paint something in a lucid dream. Or I might be designing a landscape in a fantasy story. It's fascinating because you don't know what you're going to be presented with: my subconscious is directing this without my conscious knowing. It's very exciting."

bed, and it uses an electroencephalogram – a non-invasive technique to measure electrical activity in the brain – to register when you drop into REM sleep. Then, the device emits a beam of ultrasound targeted at the dorsolateral prefrontal cortex, one of the brain regions thought to be active during lucid dreams.

"It's very precise in terms of its effect space, so that's part of the appeal," says Prophetic founder Eric Wollberg. "But people have also done surveys on what sounds more appealing or more scary, in terms of these different neuromodulation techniques. With ultrasound, people think about a sonogram on a mother's womb. I'm not electroshocking my brain."

In the short term, Wollberg is thinking about how many headbands he can sell. "If you can build a device that induces lucid dreaming, it's just a very compelling offer," he says. "I think people are going to do this because it's fun: you can do things like fly. It's just a hedonically pleasurable experience."

But he's also looking ahead and looking deeper. Wohlberg thinks lucid dreaming is much more than a playground, or even a clinic. He sees the dream world as a laboratory. "I consider lucid dreaming a particle accelerator for consciousness," he says.

DECODING CONSCIOUSNESS

Could lucid dreaming really help us understand consciousness, one of the deepest mysteries of the Universe? It's not out of the question, Paller says. "If you're in the waking state, most people think your consciousness is giving you a readout of what's in the world. You look around, you see the world and your brain has this sophisticated ability to take in all this input and read out what's out there. If you think about dreams, well, actually, your brain has that capability even without any sensory input."

Which rather begs the question: cutting-edge headset or not, how do you know you're not dreaming right now? **SF**

by **IAN TAYLOR**
Ian is a freelance science writer and the former deputy editor of BBC Science Focus.

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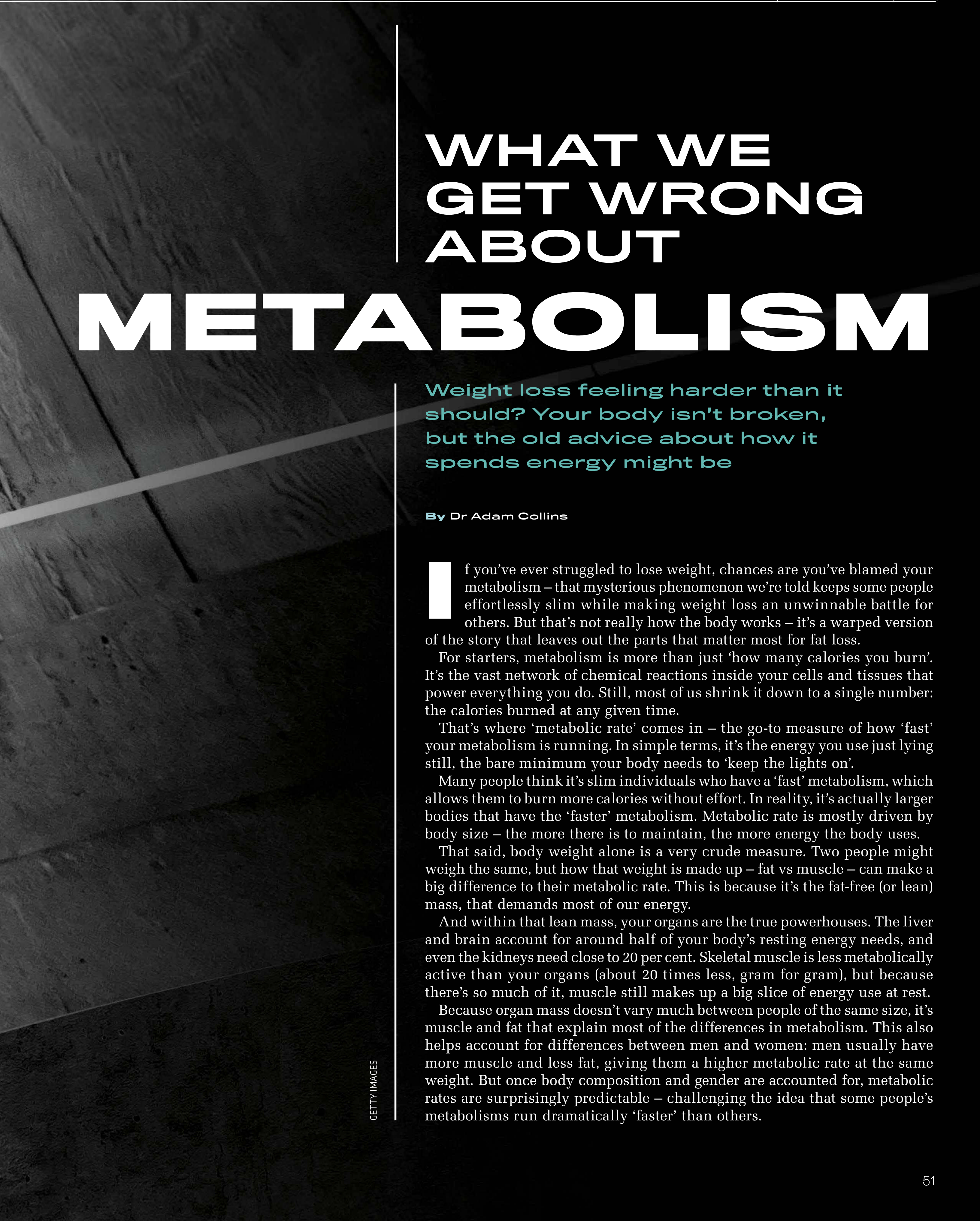

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WHAT WE GET WRONG ABOUT METABOLISM

Weight loss feeling harder than it should? Your body isn't broken, but the old advice about how it spends energy might be

By Dr Adam Collins

If you've ever struggled to lose weight, chances are you've blamed your metabolism – that mysterious phenomenon we're told keeps some people effortlessly slim while making weight loss an unwinnable battle for others. But that's not really how the body works – it's a warped version of the story that leaves out the parts that matter most for fat loss.

For starters, metabolism is more than just 'how many calories you burn'. It's the vast network of chemical reactions inside your cells and tissues that power everything you do. Still, most of us shrink it down to a single number: the calories burned at any given time.

That's where 'metabolic rate' comes in – the go-to measure of how 'fast' your metabolism is running. In simple terms, it's the energy you use just lying still, the bare minimum your body needs to 'keep the lights on'.

Many people think it's slim individuals who have a 'fast' metabolism, which allows them to burn more calories without effort. In reality, it's actually larger bodies that have the 'faster' metabolism. Metabolic rate is mostly driven by body size – the more there is to maintain, the more energy the body uses.

That said, body weight alone is a very crude measure. Two people might weigh the same, but how that weight is made up – fat vs muscle – can make a big difference to their metabolic rate. This is because it's the fat-free (or lean) mass, that demands most of our energy.

And within that lean mass, your organs are the true powerhouses. The liver and brain account for around half of your body's resting energy needs, and even the kidneys need close to 20 per cent. Skeletal muscle is less metabolically active than your organs (about 20 times less, gram for gram), but because there's so much of it, muscle still makes up a big slice of energy use at rest.

Because organ mass doesn't vary much between people of the same size, it's muscle and fat that explain most of the differences in metabolism. This also helps account for differences between men and women: men usually have more muscle and less fat, giving them a higher metabolic rate at the same weight. But once body composition and gender are accounted for, metabolic rates are surprisingly predictable – challenging the idea that some people's metabolisms run dramatically 'faster' than others.

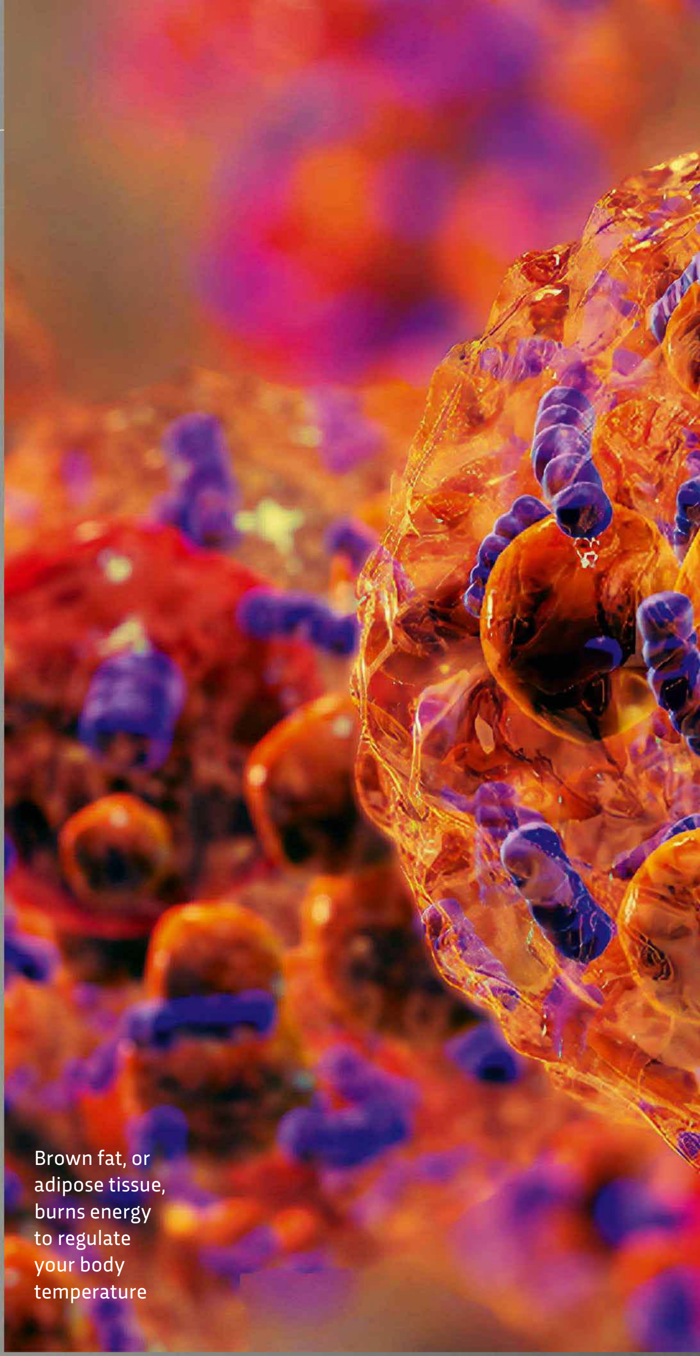
THE SLOWDOWN MYTH

A common belief is that your metabolic rate slows with age. But in relative terms, this isn't really true, especially across middle age. When you account for body composition, metabolic rate stays steady right up until around 65. Any decline before then is down to changes in muscle and fat, not some mysterious 'ageing metabolism'.

That said, some life changes can affect metabolism as we age, most notably menopause. The hormonal shifts that come with it often promote fat gain, particularly around the abdomen, and may also lead to some loss of muscle. Both can reduce metabolic rate. There's also evidence that falling oestrogen levels may slow metabolism by altering heat-producing processes known as thermogenesis, which may explain hot flushes.

Beyond 65, a slowdown in energy use becomes more likely. This isn't so much the metabolism 'ageing', but rather the knock-on effect of wider changes in the body. Muscle mass tends to decline more rapidly, and both muscle and organs become less metabolically active, reducing overall calorie burn. The good news is that staying active, eating well and working to preserve muscle mass can help manage the decline.

> "HORMONAL SHIFTS THAT COME WITH AGEING OFTEN PROMOTE FAT GAIN"

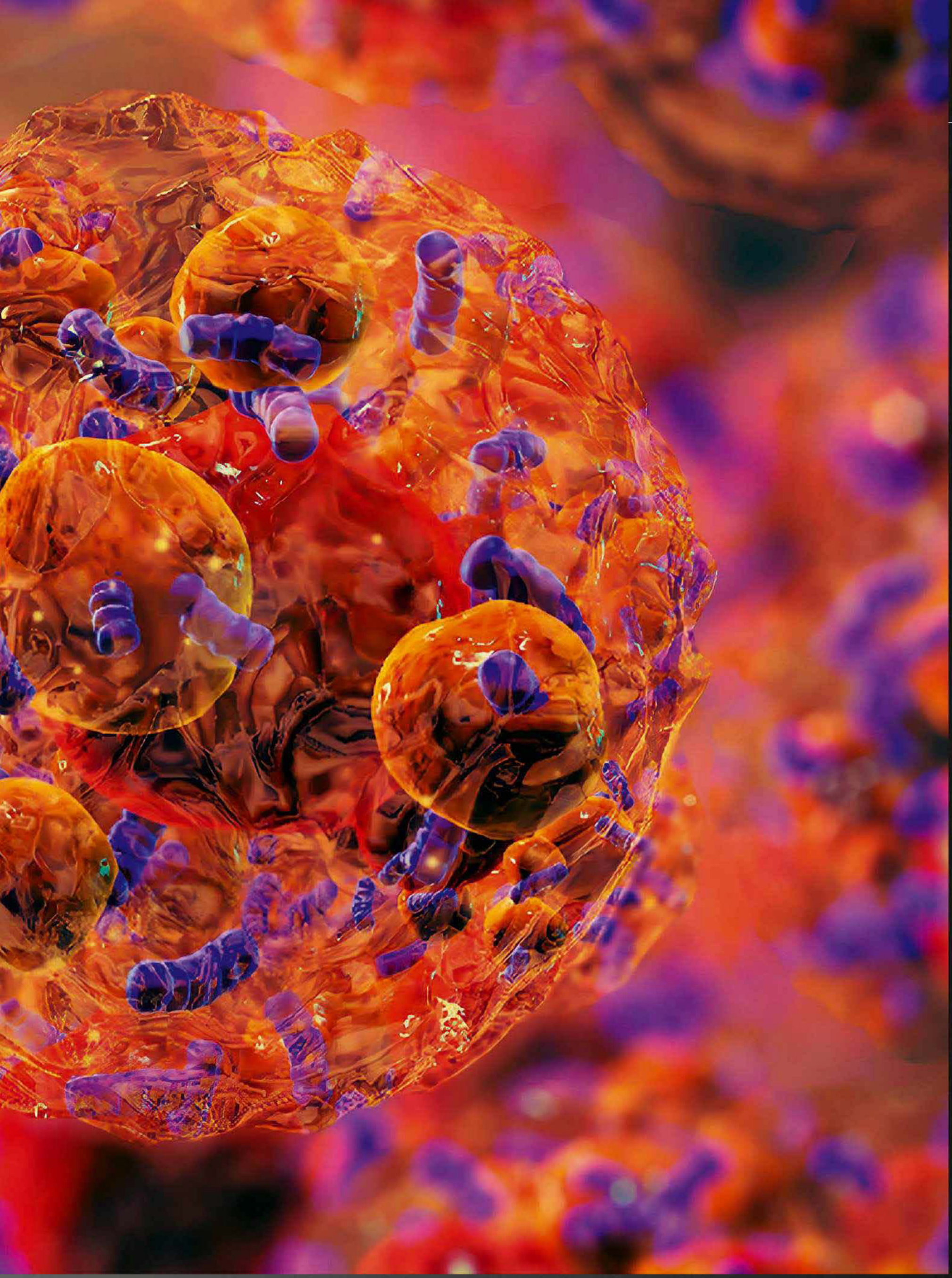


Brown fat, or adipose tissue, burns energy to regulate your body temperature

BUILT-IN BALANCING ACT

If metabolism is mostly predictable, does that mean it's completely fixed? Not quite. Your body can nudge calorie burning up or down a bit, depending on circumstances.

Take someone who's overweight. They naturally burn more calories because there's more tissue to maintain, but studies also suggest their bodies may also turn the dial up a little further, almost as if trying to shed the surplus. At the other end of the scale, underweight people often burn marginally fewer calories than expected, because they've dialled their metabolic rate down further, becoming super frugal with energy.



How is this possible? Some research suggests the body has ways to deliberately waste energy by releasing it as heat, a process known as adaptive (or facultative) thermogenesis. This involves specialised fat cells called brown fat, and the activity of certain proteins in muscle and other tissues that essentially let more (or less) calories 'leak' away as heat, instead of being stored.

You don't notice this heat leaking away as sweat or a fever – it's a quiet, behind-the-scenes adjustment that fine-tunes energy balance.

Adaptive thermogenesis doesn't mean you're trapped at a fixed weight. But it does explain why dieting feels like swimming against the tide: cut calories and your body tends to push back by slowing its metabolism, making progress harder to sustain.

So the real question is: can you do anything to change your metabolism – and if so, what really works?

by **DR ADAM COLLINS**

Adam is the Associate Professor of Nutrition at the University of Surrey. He has been a qualified nutritionist for over 20 years.

NO MAGIC MENU

Whether it be spicy foods, chilli extracts, caffeine or polyphenols in green tea, you've probably heard that certain foods can 'speed up' your metabolism, increasing calorie burning through thermogenesis. However, measured calorie increases from these ingredients are so small they are only just detectable, plus they're short-lived, lasting minutes or hours at best.

Then there's protein, which you might have heard being championed, such that eating more of it can help boost your metabolism. The thinking here is that the calorie cost of digesting and absorbing protein is higher than that of carbs and fat, suggesting you may not gain as many calories. But, again, while this is true, any discrepancy in overall calorie burning is pretty negligible.

Some point out that eating protein helps preserve and build muscle, which – as we've seen – supports a higher metabolic rate. But muscle growth doesn't come from protein alone. It needs the stimulus of exercise, particularly resistance training, to trigger muscle repair and growth.

Indeed, as well as maintaining muscle mass, exercise or physical activity is a more guaranteed way of elevating your metabolism, in an obvious way, by increasing your body's use of energy (calories, essentially).

But exercise contributes more than simply the calories burned during the movement itself. After exercise, your metabolism remains elevated as you recover, and your muscles adapt to the previous stress of exercise. This is measured as your excess post-exercise oxygen consumption (EPOC), commonly referred to as the 'afterburn' effect of exercise. This essentially increases fuel and calorie use, an effect that can persist for several hours after exercise (even as long as 48 hours) – particularly when that exercise requires you to repair and build muscle.

It's not the shortcut many hope for, but when it comes to metabolism and fat loss, exercise – especially the kind that challenges and rebuilds muscle – is by far the most effective tool.

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CAN YOU BREATHE YOUR WAY TO BETTER HEALTH?

Breathing is something we do unconsciously. But knowing when and how to take conscious deep breaths could unlock a host of benefits

by **DR HELEN PILCHER**

Right now, it feels like breathing is having a moment. Everyone's at it, but some people are really putting in the elbow grease. Rather than 'just' breathing automatically, a growing number of devotees now practise deliberate exercises.

With fancy names, such as coherent breathing or cyclic sighing, breathwork has become one of the fastest-growing trends in the wellness industry. Breathing studios are popping up in cities all over the world and breathwork gurus, such as extreme sub-temperature athlete Wim Hof, are becoming household names.

Bold claims are being made. "There's a lot of hype about breathwork changing your life," says Dr Guy Fincham from Sussex University, who studies the health benefits of breathwork. Some say it can boost the immune system, banish ill health and, perhaps, even lengthen life. But can it? What's the truth behind these breathwork fads? And could we all benefit from breathing a little differently?

BREATH BEGINNINGS

We all take about 20,000 breaths per day, but we don't all breathe the same. Some people can do extreme things with their breath. The Danish freediver Stig Severinsen, for example, can hold his breath for more than 20 minutes, while the Haenyeo (translated literally to 'women of the sea') of Jeju, South Korea, spend more time underwater – up to 10 hours per day (not all at once) – than some diving animals.

You may think that the way you breathe is nothing special, yet your breath is as unique as your fingerprints. In a recent study, scientists found that patterns of inhalation and exhalation are so distinct, they can be used to predict people's identity, as well as health-related factors, such as depression and body mass index.

Now, researchers are becoming increasingly interested in how people's breathing patterns affect their bodies, as well as their state of mental and physical wellbeing. "Scientists have been studying breath in the context of meditation for decades," says Fincham, "but now it's being studied in its own right. I think we're at a cusp where the amount of research is going to explode."

Modern breathwork has ancient roots. Over 3,000 years ago, ancient Hindus described sophisticated breathing systems, known as prānāyāma, that were said to promote health and extend life. Around 2,000 years ago, a Taoist text called the *Liezi* emphasised our breath's ability to heal. Passed down and modified through the years, these breathing exercises are now a staple of many disciplines, including yoga, martial arts and sports training.

Methods fall into one of two broad camps. Slow breathing techniques, such as coherent breathing and alternate nostril breathing, involve fewer than 10 breaths per minute. Fast-breathing techniques, like those embraced by Wim Hof, involve more than 10 breaths per minute.

Dr Richard Brown first encountered breathwork when he was a child, learning Japanese karate. Here, slow breathing was used to help focus the mind. Then, when Brown grew up and became a psychiatrist, he started to use breathing techniques in his clinical practice in New York. As did his wife, fellow psychiatrist, Dr Patricia Gerbarg.

"BOTH STUDIES HINTED THAT BREATHING IS A WAY TO DIRECTLY COMMUNICATE WITH THE NERVOUS SYSTEM"

Around 20 years ago, the duo started combining breathwork with their standard treatments, such as medication and psychological therapies. The results were transformative. Depression lifted. Anxiety eased. Patients with entrenched post-traumatic stress disorder (PTSD) found they could talk about and process their trauma. "When PTSD experts looked at our data, they said *nothing* works like this," says Gerbarg.

When 9/11 happened, the duo used their approach to help many of those who were affected, including survivors, their families and first responders. In these cases, the pair observed improvements to mental and physical health. A few rounds of slow breathing each day, for example, helped those with ground-glass lung – a painful, chronic cough caused by the debris – to improve.

A TALE OF TWO SYSTEMS

Drawing on the latest neuroscientific research, Brown and Gerbarg put forward an explanation for the encouraging results they were seeing. Breathwork, they said, helps to regulate two key parts

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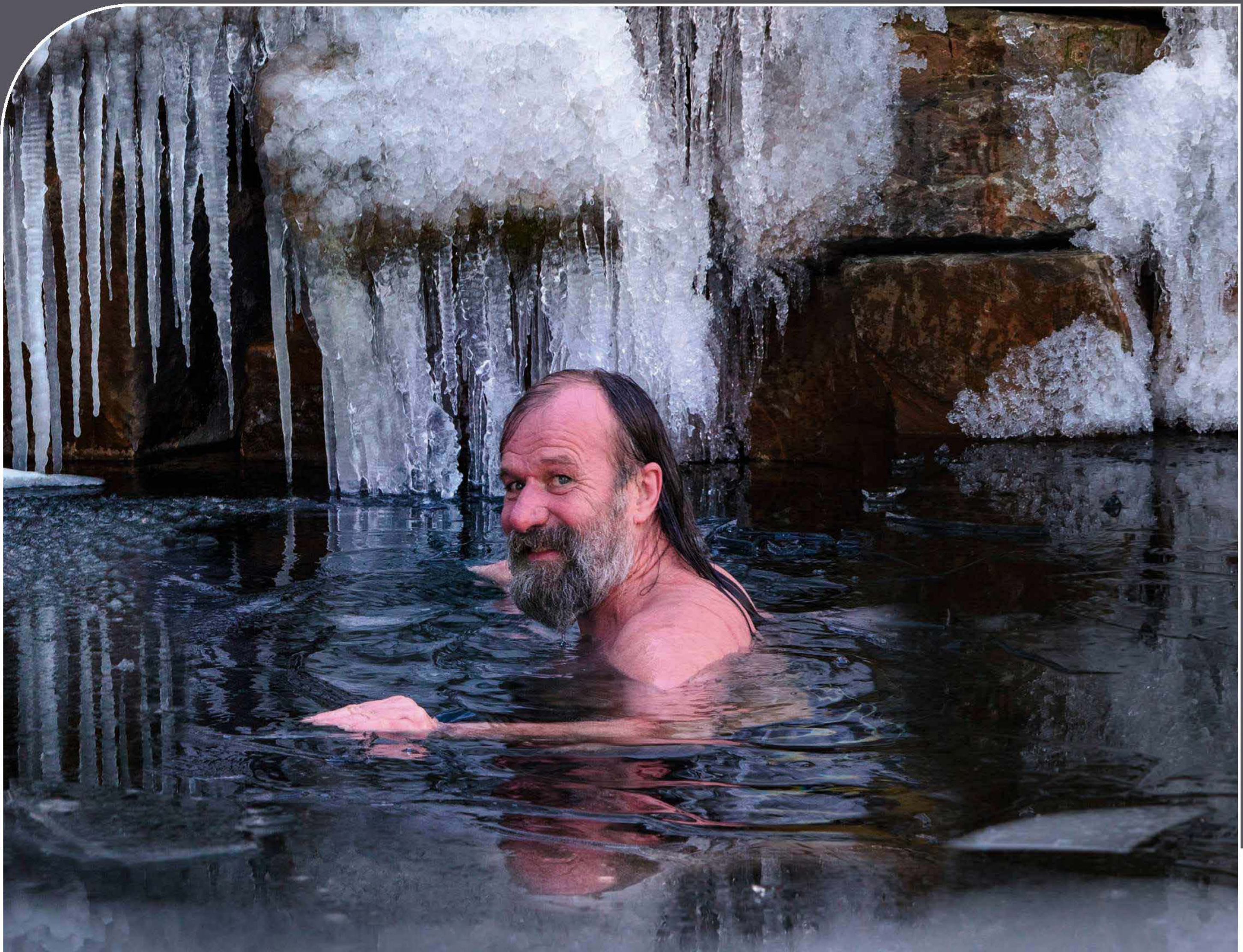


ABOVE The Haenyeo women of South Korea earn a living by fishing, often spending hours each day diving without breathing apparatus

LEFT Wim Hof says breathing exercises are a key part of his preparation for enduring very low temperatures

of the nervous system: the sympathetic and parasympathetic systems.

The sympathetic system controls the body's fight-or-flight reaction. It kicks in when we're stressed and it's great in small doses. Adrenaline levels spike, the heart rate speeds up and levels of inflammation decrease. This primes the body for action, but if we stay stressed for too long, pro-inflammatory pathways become activated and inflammation levels rise.

The parasympathetic system, on the other hand, calms the sympathetic system down. Controlled by the vagus nerve, which sends signals from the brain to the body, this system slows the heart rate and eases inflammation.

According to their theory, breathwork helps these two systems to become balanced so that everything becomes optimal. Not too much sympathetic activation and just the right amount of parasympathetic activity.

The theory made sense, but there was just one problem. At the time, scientists thought it was impossible for a person to control these systems consciously. The generally held belief was that the two systems operated automatically, beyond conscious control.

But then two studies came along which challenged that view.

In 2015, Gerbarg and Brown taught 16 patients with inflammatory bowel disease a handful of slow-breathing methods that they then practised for six months. Compared with a control group, who didn't learn breathing methods, they went on to experience less pain, stress, anxiety and depression. Critically, their symptoms improved and they had significantly lower levels of a protein called CRP, which is a marker of inflammation.

Some of these patients went on to have exploratory colonoscopies, where a camera is used to look inside the large intestine. Much to everyone's surprise, the red, inflamed tissue that had been the source of so much misery had gone. "These were people who had been on heavy medications. Some had had sections of their bowels removed," says Gerbarg. "To see this sort of improvement was exciting and validating."

Around the same time, Dutch researchers enlisted the help of 'the Iceman' Wim Hof for a different study. Hof taught his fast-breathing methods to a group of healthy volunteers, who were then deliberately injected with a bacterial toxin to cause some inflammation. The team wanted to see if breathing exercises could help to calm this inflammation down and, sure enough, it did. Compared with a control group, who didn't do the exercises, Hof's students had a stronger anti-inflammatory response and increased levels of noradrenalin – both signs of an acutely active sympathetic nervous system.

Both studies hinted at the previously unthinkable: that breathing is a way to directly communicate with the nervous system. Deliberate breathwork can be used to control the activity of the sympathetic and parasympathetic systems, influence the activity of the immune system and rein in unwanted inflammation.

Chronic inflammation is like a smouldering fire. Left unattended, it can cause serious harm. Low-level, persistent inflammation has been implicated in many diseases, including depression, diabetes and heart disease, where it often precedes the onset of symptoms. So, the question that arises is this: can breathwork be used to help prevent or treat inflammatory conditions like these? And if it can, what's the best type of breathwork to use?

BREATHING FOR THE BODY

Gerbarg and Brown shy away from fast-breathing methods, because they've found they can be triggering for some of their patients. Some bipolar patients, for example, can become manic. Wim Hof himself says that his method, which involves three to four cycles of 30 fast, deep breaths followed by a long breath hold and then a 15-second recovery breath, should not be done near water or while driving, because it can cause temporary loss of consciousness. This method can be really helpful for some people, but it comes with risks and isn't for everyone.

Slow-paced breathing practices offer a safer, less intensive alternative (see 'Do Try This at Home', on p58). Gerbarg and Brown recommend coherent breathing, which involves breathing at a

DO TRY THIS AT HOME

Here are five simple breathing exercises you can try for yourself. They're all slow-breathing techniques, chosen for their soothing effects. Unless stated otherwise, they're best done through the nose. If you have any relevant health concerns, such as asthma or a deviated septum, please check with your doctor before trying these exercises.

COHERENT BREATHING

Coherent breathing, also known as resonant breathing, is a slow, rhythmic pattern of breathing designed to place the heart, lungs and circulatory system into a state of coherence, where the systems of the body work at peak efficiency. This is one of the easiest breathwork methods to do and has been shown to have many health benefits, including reducing stress and calming anxiety.

HOW TO DO IT...

1. Breathe in slowly and gently through the nose for five to six seconds. Focus on using your diaphragm and lower belly to create a deep, full breath.
2. Breathe out slowly through the nose for five to six seconds.
3. Repeat at least 10 times. Each breath should feel like a continuous cycle, with no pauses.

CYCLIC SIGHING

Every five minutes or so, we all naturally take a deeper breath – called a sigh – which is larger than our typical breaths. These involuntary sighs help to maintain the fine structure of the lungs. Cyclic sighing, which starts with a double inhale, builds on this phenomenon. A 2023 study found that cyclic sighing is better at improving mood and reducing stress than mindfulness meditation.

HOW TO DO IT...

1. Breathe in deeply through your nose until your lungs are almost full.
2. Take a second, quicker top-up breath. Your lungs should now be full.
3. Exhale fully through the mouth in a slow, controlled manner. This should take about twice as long as the inhales.
4. Repeat the cycle for around three to five minutes daily.

rate of five to six breaths per minute.

This is best done through the nose, rather than the mouth. "The nose is made for comfortable respiration," says nasal surgeon Dr Jayakar Nayak from Stanford University. "It's constantly filtering, humidifying and warming the air." In addition, when you breathe through the nose, nitric oxide produced in the sinuses is carried to the lungs, where it dilates the blood vessels and leads to better circulation. Mouth breathing, in contrast, doesn't have this effect.

Anders Olsson, founder of Conscious Breathing, points out that when you breathe slowly and rhythmically through the nose, you exhale less carbon dioxide and so retain more in the body. This can be a good thing. "We think of oxygen as a hero and carbon dioxide as a villain," says Olsson, but that's not right.

"Carbon dioxide is much more than 'just' a waste gas," he adds. It's not a lack of oxygen, but a build-up of carbon dioxide that prompts us to take our next breath. Optimal carbon dioxide levels help to keep the airways open and

RIGHT Alternate nostril breathing is based on a yogic technique and is said to have calming effects

ALAMY

ALTERNATE NOSTRIL BREATHING

Alternate nostril breathing, also known as Nadi Shodhana, is an ancient yogic breathing technique. Due to its calming effects, the method can be helpful in stressful situations or as a way to help drift off to sleep.

HOW TO DO IT...

1 Use the thumb on your right hand to close your right nostril. Inhale slowly and deeply through your left nostril.
2 Close your left nostril with your right ring finger. Release the right nostril and exhale slowly through the right nostril.
3 Inhale slowly through the right nostril.
4 Close the right nostril with your thumb. Release the left nostril and exhale slowly through it.
5 Repeat five to ten times.

NASAL WALKING

Go on a walk, but breathe only through your nose. Nasal breathing helps to warm, humidify and pressurise the air while improving respiratory efficiency and building tolerance to carbon dioxide.

Pick up the pace a little and this becomes more difficult. Alternatively, keep at your original pace, but take twice as long to exhale as to inhale. For example, breathe in to the count of four, but breathe out to the count of six.

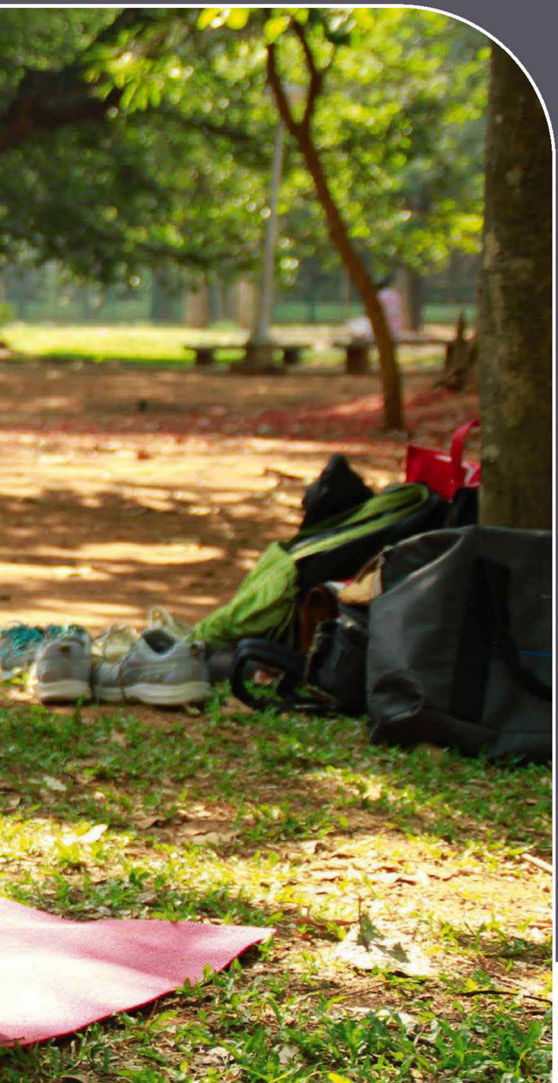
As carbon dioxide levels increase, this can create a feeling of deep relaxation, described by some as being like a runner's high. It's also a bit like training at altitude, but without the hike up a mountain.

4-7-8 BREATHING

Rooted in the ancient yogic practice of prānāyāma, 4-7-8 breathing can be used to help reduce anxiety, improve sleep and promote a state of deep relaxation. A 2022 study found that 4-7-8 breathing lowered blood pressure and improved heart rate variability (a measure of sympathetic and parasympathetic balance, predictive of future health) in healthy young adults.

HOW TO DO IT...

1 Inhale through your nose for the count of four.
2 Hold the breath for a count of seven.
3 Exhale through your mouth, with a whoosh sound, to the count of eight.
4 Repeat this cycle another three times. Practise twice a day.



"NO ONE IS DENYING THE CALMING EFFECTS THAT SLOW BREATHWORK CAN BRING"

prompt the release of oxygen from the haemoglobin molecules where they're lodged. Carbon dioxide also helps to protect mitochondria, the cells' power plants, from being damaged and keeps them working effectively.

Multiple studies have now shown that the slow breathwork practice of coherent breathing can help those suffering from anxiety, stress, depression, PTSD, insomnia, burnout and binge eating disorders. And while there are no direct studies linking breathwork with chronic physical diseases or longevity, there are indirect links.

Through its ability to hack the nervous system, coherent breathing is known to increase something called heart rate variability (HRV), which is the variation in time between consecutive heartbeats. Higher HRV, in turn, is associated with lower blood pressure, lower levels of inflammation and improved heart health. Lower HRV, meanwhile, is predictive of poor heart health and early death.

The more scientists learn about the effects of breathwork on the body, the more reasonable it seems that breathing techniques really could help to stave off diseases that have an inflammatory component, such as heart disease and Alzheimer's, and, perhaps, even help to lengthen life.

Further research is needed, but in the meantime, no one is denying the calming effects that slow breathwork can bring. As Olsson says, "Breathe slowly and rhythmically through the nose and engage your diaphragm – it's not just about health. It's about peace." **SF**

by **DR HELEN PILCHER**

Helen is an author and science communication consultant. She has a PhD in cell biology. Her next book, This Book May Cause Side Effects, *will be published in 2026.*

Welcome to WHIP

LASH Weather

Weather patterns are see-sawing from one extreme to another faster and more frequently than ever before, with increasingly deadly consequences. And the phenomenon is coming to places you wouldn't expect

by **PROF BILL McGUIRE**

GETTY IMAGES X2

California is no stranger to wildfires, but January 2025 saw some of the worst yet. Supercharged by global heating, more than a dozen fires raged across the Los Angeles metropolitan area and around San Diego, driven by hot Santa Ana winds reaching speeds of 160km/h (100mph).

Hundreds of thousands of people were evacuated and more than 16,000 homes and other buildings were destroyed – some owned by celebrities, including Billy Crystal, Jeff Bridges and Anthony Hopkins. The fires killed 31 people, but another 400 or so are thought to have died due to indirect effects of the fires, most notably the poor air quality.

While the fires took just a few weeks to do their worst, it had taken years to set the stage for their appearance. For the last decade or so, extreme drought was the order of the day across much of southern California. But then the weather flipped, bringing exceptionally heavy rainfall in 2022 and 2023, which resulted in an explosion of growth across forest, brush and grassland.

Then, in 2024, conditions flipped back again, bringing California's hottest summer on record. This was followed by extremely dry weather in the autumn and early winter, which saw next-to-no rain in downtown LA. By January 2025, there was a huge quantity of tinder-dry vegetation, just waiting for a spark to launch a conflagration and, inevitably, it came.

What made the fires even worse is the fact that, for every 1°C (1.8°F) the planet heats up, the atmosphere is able to absorb seven per cent more water. In 2024, the world was more than 1.5°C (2.7°F) hotter than pre-industrial times. Hotter air can hold more water, so as the temperature climbs, the atmosphere acts like a sponge, sucking even more moisture out of vegetation and soils. This means that when the rain does eventually fall, it's much more intense, which in turn, encourages more plant growth that provides fuel for fires.

Living in the UK, I'm more than familiar with changeable weather, to the extent that it's one of the main topics of conversation here. It's not unusual to experience sunshine, snow, rain and hail on the same day, sometimes even within the hour. But the variability of the Great British weather can't hold a candle to the switches from drought to deluge and back to drought again that paved the way for the California wildfires – switches that are driven by ever-climbing global temperatures.

Call it global weirding or whiplash weather, it amounts to the same thing: the world's weather is in turmoil. It means sudden flip-flopping is becoming more common, causing widespread damage and disruption, and playing havoc with people's lives and livelihoods.

AN OLD THREAT, BUT NEWLY STRONG

In truth, there has always been whiplash weather. Rapid thaw and flood have brought to an end some of the coldest and snowiest UK winters, while intervals of extreme heat have long been broken by intense rainfall and floods fed by colossal thunderstorms.

But like pretty much every type of weather, this whiplash element has been supercharged by global heating. Nowadays, longer and hotter heatwaves are ended by even more extreme rainfall, and followed by bigger and more dangerous floods.

This is just one aspect of how, as Earth gets steadily hotter, our weather is becoming more extreme, more destructive and increasingly deadly. In 2024 alone, the cost of recovery and rebuilding due to climate-related disasters cost the US almost $1 trillion. By mid-century, it's estimated that extreme weather will cost a mind-boggling $38 trillion a year worldwide, almost one third of global GDP today. And much of this loss will be a result of whiplash weather, which is already having an effect on the planet.

So, why is whiplash weather happening more often now? Ultimately, it all comes down to the 40-plus billion tonnes of carbon dioxide – approximately equivalent to the weight of 800,000 *Titanics* – that

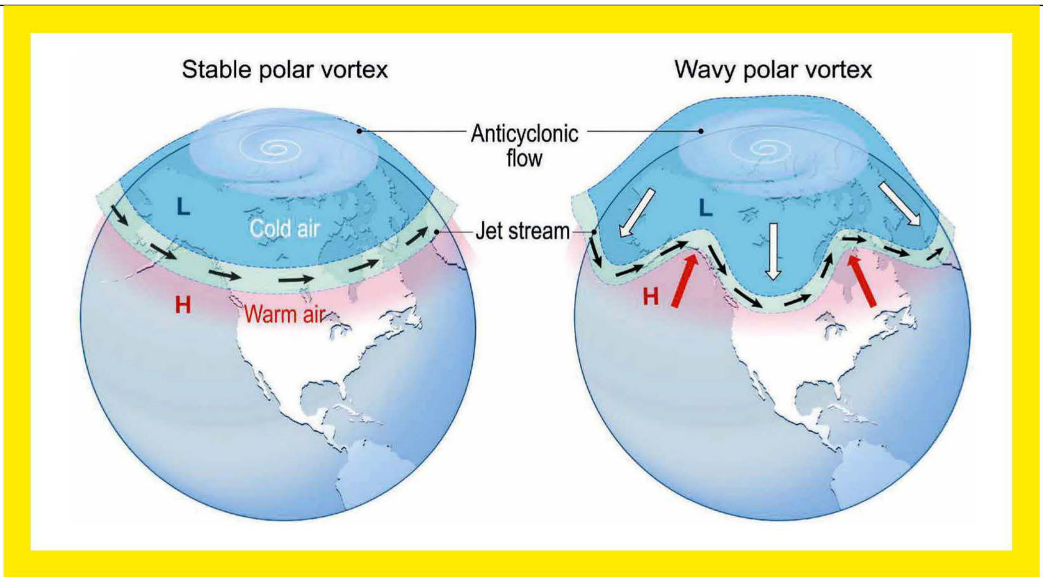
RIGHT Multiple wildfires raged across California in January 2025

BELOW RIGHT The Palisades fire left a trail of devastation in its wake

BELOW LEFT Heavy rain after the January 2025 fires had cleared much of California's vegetation, left parts of the state prone to flooding

GETTY IMAGES X3

Wildfires blazed across parts of north-west Spain during August 2025. Though not unusual, this year's blazes were particularly hard to contain



ABOVE Swings in the polar jetstream are causing wilder temperature fluctuations in more northerly latitudes

BELOW The 'Pineapple Express' delivers heavy rain to much of California

we pump into the atmosphere every year, mostly from burning fossil fuels. As a consequence, the planet is heating at an accelerating rate, driving fundamental changes in the way our weather works.

In the northern hemisphere, the polar jetstream – a narrow band of 320km/h (200mph) high-altitude winds that keeps the freezing Arctic air in place – is beginning to experience wild swings. At temperate latitudes, in places such as southern Canada and the northern US, alongside the UK and western Europe, this can bring sub-tropical air and heat one week, followed by a plunge of polar air and snow the next. Increased meandering of the north polar jetstream is attributed to an evening out of temperatures between the equator and the poles as the planet gets hotter.

And this isn't the end of the bad news. Crucially for California, extremely dry episodes are set to be ended more often by very wet conditions. These are brought to the area by long ribbons of exceptionally moist air, known as 'atmospheric rivers', including the infamous Pineapple Express, which starts off in the vicinity of Hawaii and can bring torrential rains to anywhere along the US west coast, and even further inland. In California, this plays a key role in feeding the growth of vegetation that can end up as fodder for fires to come.

An increase in whiplash conditions in many parts of the world is also expected to result from future changes in the frequency and strength of El Niño conditions, which involve abnormal warming of the tropical Pacific Ocean. All-in-all, the breakdown of our once stable climate as a consequence of global heating is pushing up the chances of whiplash weather pretty much everywhere.

A WORLD OF PROBLEMS

California is one of the world's hotspots for wildfires and it's clear that this is set to continue as whiplash weather becomes the normal state of affairs in the decades ahead. As well as exacerbating wildfire activity in other places already severely affected, such as Australia and southern Europe, the concern is that whiplash weather will mean that wildfires will also become a growing problem in cooler parts of the world, like the UK.

This year has already seen a record number of fires in the UK, which, together, have burned an area of 460km^2 (177 sq miles) – an area more than twice the size of the city of Glasgow.

A particular worry is that the effects of whiplash weather on parkland, recreation space and gardens will make cities in the UK, and other countries with a temperate climate, vulnerable to what are becoming known as 'firewaves' – multiple separate fires triggered across major urban centres once the conditions are right.

But the problems that whiplash weather is causing aren't just limited to aggravating wildfires. It's also set to have an impact on societies and economies in every corner of the world.

In a landmark scientific paper published in the journal *Nature* earlier this year, Dr Daniel Swain, of the University of California, and co-authors showed that what they refer to as 'hydroclimate whiplash' (flip-flopping between wet and

GETTY IMAGES X2, NOAA

LEFT Heatwaves in Kenya ruined many subsistence farmers' crops in 2023, before heavy rainfall in 2024 devastated farmland

ABOVE Droughts are already threatening agriculture in places like Eritrea. The effects of climate change will only worsen the situation

dry conditions) has already increased across the world by between a third and two-thirds compared to the middle of the last century. Furthermore, they warned that this trend is set to continue.

For a 3°C (5.4°F) hike in global temperature, compared to pre-industrial times – which is possible, even likely, by 2100 – land areas are predicted to see within-season whiplash rise by up to 130 per cent, with year-to-year flips happening 50 per cent more often than at present.

This will bring all sorts of problems, especially for food production, and particularly in north and central Africa, the Middle East and South Asia, which support big and often vulnerable populations.

More than 800 million people already go to bed hungry every night and whiplash weather is certain to increase this number. East Africa is already struggling, as severe drought in 2022 and 2023, followed by torrential rain and serious flooding, devastated harvests, leaving up to 20 million people without enough to eat, and more than two million homeless.

Such a pattern, of too little rain followed by too much, makes it all but impossible to farm and is set to make growing food increasingly difficult in the decades to come – particularly in nations that are home to the majority of the world's populations, which are already struggling to grow enough food. Whiplash weather will undoubtedly be a major contributor to plunging global crop yields, which, according to a 2021 report by the UK thinktank Chatham House, could be down 30 per cent by mid-century. A chilling statistic, if ever there was one.

LASTING CONSEQUENCES

While agriculture will bear the brunt of flip-flopping weather, urban centres will be far from immune. A 2025 study by the charity WaterAid, revealed that around one in five of the world's most populated cities – including Dallas, Shanghai and Nairobi – is now experiencing whiplash weather, in the form of rapid switches between drought and torrential rainfall. Water is the lifeblood of big urban centres, but too much of it, or too little, can bring all sorts of problems, especially where often ageing or inadequate infrastructure is unable to handle the new conditions. Inadequate drainage can lead to serious flooding, sewage into the streets and the spread of disease, while also impacting power and drinking water supplies. In the worst cases, it can lead to a breakdown of law and order.

The bottom line is that whiplash weather is not only here to stay, but it's getting worse. It won't stop even when, or if, emissions are brought to heel, because whatever temperature Earth has reached by then will be maintained for thousands of years, so we have no choice but to live with it. Is there, then, anything we can do to manage its impact and mitigate its worst effects? Well, yes – quite a bit in fact, provided we're prepared to make the effort and spend the cash.

30%

THE DROP IN GLOBAL CROP YIELDS BY 2050 DUE TO WHIPLASH WEATHER

The problem is that we need to be able to handle two weather extremes – too much rain and too little – which is never going to be easy, especially for agriculture. Finding new ways of saving water for use during drought is a no-brainer, for example, by harvesting and storing rainwater. But preventing flooding caused by torrential rains is harder.

The best way, as is often the case, is to let nature take its course, by allowing rivers to flood naturally across their floodplains during wet periods. Not only will this provide a source of water that may be accessed for use during droughts, but it'll also reduce the flood risk to communities and infrastructure downstream. Towns and cities need to become sponges, so permeable surfaces should be the order of the day, allowing water to infiltrate rather than run off. Not only would this reduce flood risk, but it could also help recharge groundwater aquifers.

ABOVE Firefighters monitor a controlled burn in California's Pacific Union College Forest

RIGHT Controlled burns of the dry foliage that could fuel a wildfire help prevent a blaze from spreading

FIRE PREVENTION

But what of California and its fires? There's actually much that can be done there, and technology could help. This includes the use of lightning detectors designed to pinpoint the location of strikes within 40 seconds, and unmanned fire-detection drones.

Better prediction of fire behaviour would also make a huge difference to the chances of controlling the flames. Artificial intelligence is being used to improve this by bringing together weather information like wind speed and direction, temperature and air pressure, with fire data gleaned from drones, aircraft and satellite-based sensors.

It's hoped all this will help stamp wildfires out early, before they have a chance to develop into monsters. This is all well and good, but it would be better if fires never started at all. Improving prevention requires better management of forest, brush and grassland, and the use of controlled burns where appropriate. Introducing fire-resistant tree species and making sure that fire-breaks are in good shape can help to slow the spread of fires, while using more fire-resistant materials in buildings and maintaining open spaces around them could limit damage.

On an ever-hotter planet, however, battling wildfires, alongside the floods and drought that whiplash weather is set to bring more of, is only going to get harder. Assuming we're serious about tackling the problem, we know exactly what we have to do: stop pumping out the carbon and pumping up the heat. **SF**

GETTY IMAGES X4

by **PROF BILL MCGUIRE**

Bill is Professor Emeritus of Geophysical and Climate Hazards at University College London and the author of Hothouse Earth: An Inhabitant's Guide *(Icon Books, 2022).*

THE TRUTH ABOUT ADULT ADHD

Attention deficit hyperactivity disorder was long thought to be something only unruly schoolkids suffered with. Now, the science is telling us a very different story

by **DR JACK GOULDER**

ILLUSTRATION: JOE WALDRON

There's a stereotype," Camilla tells me, "which is that if you're not a complete screw-up, you can't have ADHD. It's particularly common among psychiatrists."

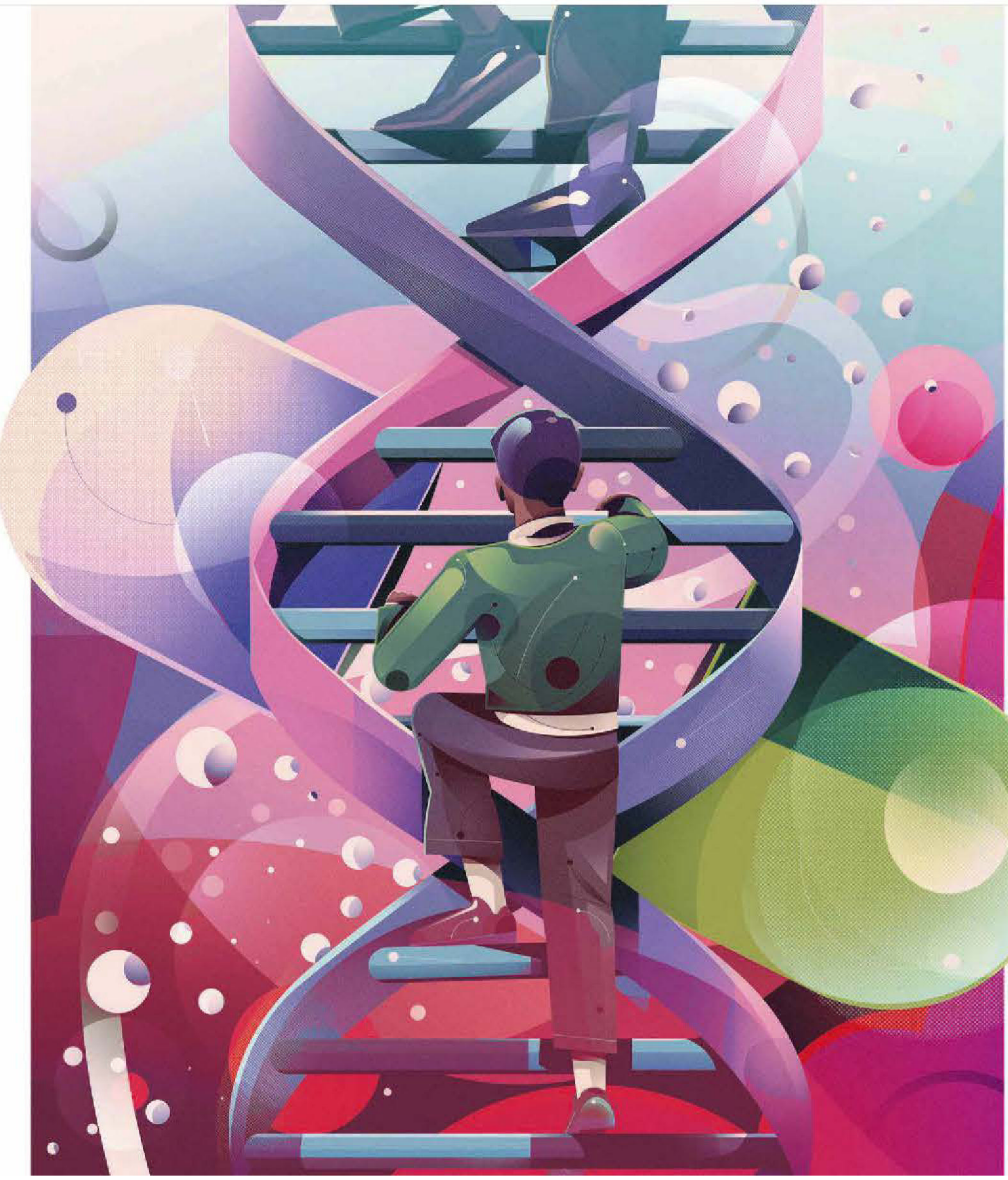
She would know. Growing up, Camilla was a model student. She got excellent grades, won a place at medical school and eventually became a psychiatry trainee and researcher. Then, towards the end of her twenties, everything suddenly came to a halt.

When the stress of a botched medical procedure combined with mounting pressures at work, she found herself burnt out and unable to do her job. "My brain just stopped working. I was putting orange juice in the washing machine instead of the fridge. I couldn't figure out the train home and kept ending up in the wrong parts of town." She ended up taking sick leave.

It was her therapist who first suggested she get an ADHD assessment. "I said, 'It feels like I'm always trying 100 times harder to be organised and I'm twice as bad as everyone else'" and something clicked in the therapist's mind.

Yet when she went to her GP for a referral, she was told: "You're a doctor and you're married, you can't have ADHD." Even though she was working in psychiatry, Camilla herself was unsure. "I thought ADHD was naughty, fidgety boys who couldn't sit still and failed at school. It just wasn't me."

For decades, ADHD was seen as a childhood disorder – marked by restlessness and inattention – that largely faded with age. Over the last 20 years, however, researchers have challenged this view. Many now see ADHD as a lifelong condition that remains under-recognised. But the idea has proved controversial.



Camilla could see the clues in hindsight. As a child, she flooded the family bathroom four times by forgetting to turn off the tap. "My parents had to re-plaster the ceiling twice." Although studious, she often zoned out of conversations and clashed with friends. "I was constantly contravening social rules. I could easily come across as stupid or rude. Most people knew my brain worked differently, there just wasn't a name for it."

When, at 28, 'it' was finally given a name – attention deficit hyperactivity disorder – everything made sense. "Every part of my life was transformed. My marriage, my friendships, my mental health, my work. Everything."

I first met Camilla when we worked together in a children's mental health clinic. I saw firsthand how disabling ADHD could be, how exhausting it was for children to be labelled 'naughty'. I also learned that diagnosis wasn't everything. Many were stuck in a stressful school system that didn't suit them. Like some colleagues, I assumed most would eventually 'grow out of it', finding a niche in an adult life they could thrive in.

Meanwhile, demand for diagnoses was growing exponentially – driven mainly by adults – fuelled by rising public awareness and social media. NHS clinics were quickly overwhelmed. Waiting times grew from months to years.

I remember feeling uneasy at how quickly ADHD seemed to be changing. And I wasn't alone. Many clinicians pushed back, especially after the diagnostic criteria were revised in 2013 to make it easier for adults to qualify.

US psychiatrist Prof Allen Frances, who oversaw the previous version of the diagnostic manual in 1991, has since become a prominent critic of the growth in diagnoses. He sounded the alarm in a recent article: "It's time to stop the adult ADHD fad before it gains even more traction."

ADHD is having something of an identity crisis. And it's not just the public: many professionals are wondering how the diagnosis has stretched so far, so fast. As both the severity of symptoms and the range of patients have expanded, some are beginning to ask what the label now means.

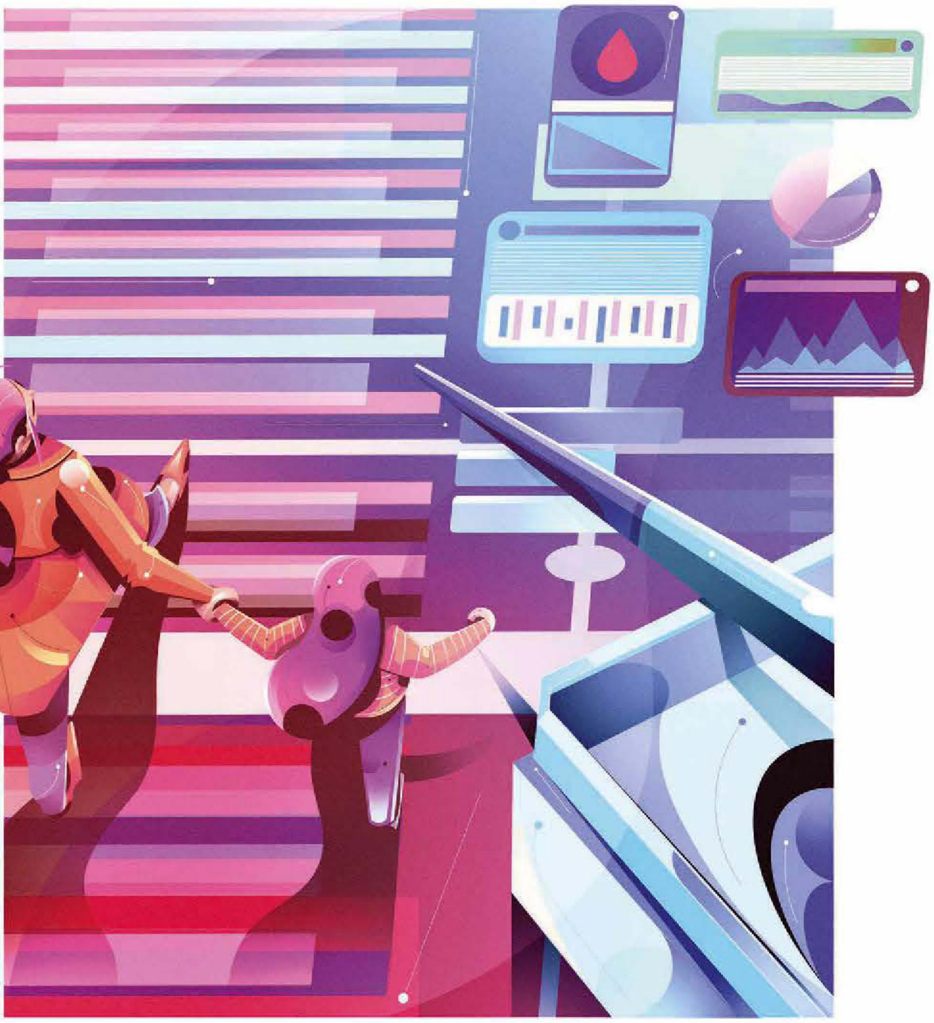
A CHANCE DISCOVERY

Fidgety, distractible children have always existed. But it was a chance discovery that led doctors to first see their behaviour as a medical problem, rather than just a lack of discipline. In the 1930s, Dr Charles Bradley, a psychiatrist caring for brain-injured children, trialled Benzedrine, a new stimulant drug, to relieve their headaches. It did nothing for the headaches, but to Bradley's surprise, many of the behavioural problems the children had developed after their injuries began to settle. They calmed down and focused in class. What's more, their grades improved.

Bradley published his findings suggesting that hyperactivity might have a neurological basis, but his work was largely ignored for years. When the diagnosis was formalised in the 1960s, it was called "hyperkinetic reaction of childhood," reflecting the belief that poor parenting or unstable homes were to blame. "Psychiatry always had this blame-the-parent thing," Prof Stephen Faraone, a leading ADHD researcher, says, "and ADHD was no exception."

ILLUSTRATIONS: JOE WALDRON

> **“GENETIC STUDIES LATER CONFIRMED THAT ADHD IS HIGHLY HERITABLE”**



Faraone recalls that when he started out in the late 1980s, “Adult ADHD was not on anyone’s radar.” Yet in his children’s clinic, parents often confided they were struggling with the same difficulties as their children. “We started conducting family studies, which showed that if you looked at the parents of kids with ADHD, you found that they often had it at far higher rates than you would expect.”

Genetic studies later confirmed that ADHD is highly heritable. Around 70–80 per cent of the variation in symptoms can be explained by genes. But when these results were published, they provoked a surprising backlash. After Prof Anita Thapar, a child psychiatrist, linked ADHD to certain genetic variants, she found herself bombarded with calls and emails. “One, from a retired head teacher, said children with ADHD should be given the slipper,” she had written. “Others accused us of being in cahoots with drug companies, of being doctors who ‘just want to drug people.’” (Neither she nor her collaborators were funded by drug companies.)

Another controversy was emerging. While the hyperactivity symptom of ADHD was more common in boys, it seemed to fade with age. Research, however, showed that it was closely linked with symptoms of inattention and impulsivity, which were just as disabling but harder to spot, so many people slipped under the radar. For a long time, ADHD was thought of as a boys’ condition, but once inattention and impulsivity were added to the mix, it became clear that girls were affected too. These less obvious symptoms were tracked as the children grew up and sometimes they improved, like hyperactivity, but just as often they remained.

When Faraone and colleagues proposed in the 1990s that ADHD could last into adulthood, many psychiatrists resisted. “No one would give us space at conferences to discuss our findings.” Yet when they did finally get space, other clinicians admitted they had often seen the signs; it was just that, up until that point, they didn't know what to make of them.

A MAJOR PUBLIC HEALTH ISSUE

Could adult ADHD really have been hiding in plain sight?

Researchers had begun to use new methods to look for mental health problems, studying not just the patients in clinics, but whole populations. "Clinicians don't really have a great sense of what's going on in the real world," Dr Ronald Kessler, the McNeil Family Professor of Health Care Policy at Harvard Medical School says. "They only see what's happening in their clinics."

Kessler has done more than almost anyone to change how we look at the long-term effects of mental illness. In 2001, he ran the National Comorbidity Survey, a study of over 9,000 people in America, which showed that while half of the children seemed to grow out of ADHD, the other half continued to show symptoms.

Further studies confirmed this and today, 3–5 per cent of the population are thought to have ADHD. The World Health Organization commissioned Kessler to repeat these studies in other countries and he found the rate remained strikingly similar wherever he looked, challenging the view

ILLUSTRATION: JOE WALDRON

many held that ADHD was a peculiarly 'American disease'.

When these people are followed up through their lives, the consequences are stark. "It's a feeder disorder," Kessler says. "You start to show symptoms of ADHD at the age of eight and they cascade into other problems." Interpersonal difficulties, for example, can trigger social isolation and depression. Symptoms may become less visible, but the distress remains real.

"All of these studies have looked at the real-world consequences of the disorder," Faraone says. "Traffic accidents, injuries, substance misuse, unemployment, suicide, criminal convictions – all more likely with undiagnosed ADHD." One recent study suggested that people with ADHD live, on average, nine years less.

Even apparently successful adults still show difficulties. "I've had patients who are lawyers or doctors – some clinicians refuse to treat them," Faraone says. Yet, in his research, he found that high-IQ adults with ADHD had higher divorce rates and lower incomes than their peers without the condition.

I thought of Camilla. "There's a very functional doctor that people see [when they look at me]," she had told me. "But they don't see the part at the end of the day that's completely exhausted from compensating. It's embarrassing to say out loud, but it's the truth."

"IN THE UK, UNTREATED ADHD IS ESTIMATED TO COST £17 BILLION A YEAR IN HEALTHCARE AND WELFARE"

In the UK, untreated ADHD is estimated to cost £17 billion a year in healthcare and welfare. Policymakers around the world have started to frame it as a major public health issue – especially since it's treatable. "ADHD medications are the most effective drugs in psychiatry," Prof Samuele Cortese, a leading researcher of neurodevelopmental disorders, says. And some of their benefits are only now becoming clear.

In a series of studies published with colleagues in Sweden, Cortese showed that when people with ADHD were treated with medication, many of the associated risks – accidental injury, substance misuse, suicide and overall mortality – were reduced. It was the first time a psychiatric medication had been shown not just to ease symptoms, but to help prevent future harm.

DIFFERENCES IN THE BRAIN

As some researchers realised the scale of ADHD's effects on a population level, others had begun to pick apart what was happening inside the brain.

After Bradley's chance discovery of the effects of stimulants, researchers studied the role of the brain's dopamine system, the main target of these drugs. Many of the genetic associations with ADHD involved dopamine-related genes and brain-imaging studies showed differences in how dopamine seemed to be regulated in those with the condition. Because dopamine is central to the brain's reward system, one theory held that altered dopamine signalling might explain why people with ADHD often struggle to wait, grow impatient with routine tasks or make impulsive decisions.

Yet rather than being explained by 'low

> **"IT COULD BE THE LACK OF A DIAGNOSIS THAT'S HOLDING MANY PEOPLE BACK"**

dopamine' alone, it became clear that larger brain networks were involved. Scientists identified a set of regions that are active during periods of rest and mind-wandering, but normally quieten down when people engage in goal-directed tasks. They named it the default mode network (DMN), sometimes colloquially called the 'day-dreaming network'.

Neuroscientists proposed that symptoms might arise from inadequate suppression of this network during daily life. Brain-imaging studies show that in neurotypical individuals, DMN activity falls away as task-focused areas light up. In people with ADHD, however, the day-dreaming network doesn't tend to switch off as effectively, interfering with the other task-focused networks. This may help explain why stray thoughts intrude just when concentration is needed, something that medication can help to reduce.

Still, there was a problem. As scientific understanding shifted, the diagnostic guidelines were stuck with the image of ADHD as a rare childhood disorder. Many experts began to push for change.

"They called in my research along with a number of others," Faraone recalls, when the American Psychiatric Association formed a new diagnostic task force. "There was a debate whether to create a new 'adult' category altogether." In the end, the 2013 updated guidance kept a single category, but lowered the threshold for adults by a single point – to account for the waning of hyperactivity.

These changes coincided with surging public awareness, driven in part by destigmatisation campaigns, but also a growing discussion on social media. #ADHD is now one of the most popular health-related hashtags on TikTok. Yet while these videos can help educate and reduce stigma, a recent study found that most of them provided misleading information.

At the same time, in the UK and elsewhere, clinics were becoming overwhelmed, with demand far outstripping capacity. In some areas, wait times for NHS services are now exceeding four years for children and more than eight for adults.

Amid the crisis, some professionals began to argue that ADHD had all the makings of a fad. "It's a case of disease-mongering," Prof Nassir Ghaemi and Dr Mark Ruffalo, two prominent US clinicians, have recently written, "when a condition that has never been observed is suddenly made popular overnight." The UK Health Secretary, Wes Streeting, recently commented that doctors might be "over-diagnosing" ADHD and other mental health conditions, preventing people with them from returning to work.

Yet the noise from social media, and the backlash it has generated, could be obscuring a far larger problem. If 3–5 per cent of the population have ADHD, it means that many people remain undiagnosed and untreated. The UK still lags behind many other European countries, like Denmark and Spain, in rates of diagnosis. And those most likely to miss out are from ethnic minorities and more disadvantaged backgrounds.

Rather than overdiagnosis, it could be the lack of a diagnosis that's holding many people back from getting on with their lives.

THE DECISION TO MEDICATE

When she started work again, Camilla felt apprehensive. "After my diagnosis, I did some coaching and therapy. It helped me be more open about the way my brain works differently and helped me explain to colleagues what I needed. It made it easier for my team and much better for my patients. It also took away a lot of the shame."

Some fear a diagnosis might lead to the over use of medication,

ILLUSTRATION: JOE WALDRON

but like many people, Camilla has chosen not to use them. "Medication never made a huge difference for me, but I've seen how useful it can be for my patients."

Cortese tells me that this was now one of the main areas of research, trying to tease apart why some people benefit more from medication than others.

"What's made the biggest difference," Camilla says, "is understanding myself – planning my day, sleep, exercise. And having a really supportive husband. That's probably the best medication!"

Experts increasingly see ADHD as the tail-end of normal human variation. Like height or blood pressure, attention and impulsivity exist on a spectrum, with most of us sitting close to the middle.

"The science clearly shows that these traits lie on a continuum. It's not black and white," Cortese says. The challenge is at what point these symptoms are considered a medical problem. "Traits themselves don't necessarily cause problems," but when they continually disrupt daily life – what doctors call 'functional impairment', "that's when we speak of a medical disorder."

What's more, as the demands of life change, symptoms can flare up or down. "We tend to see spikes in referrals at certain points in life when people face new challenges," says Faraone. "For example, when a family has their first child, or during life transitions like starting a first job or moving to university."

All of this means that symptoms don't always need medication, they could be better helped in other ways. In a bid to tackle waiting lists, an NHS task force, chaired by Thapar, recently recommended a radical overhaul of how those with ADHD are supported. Many people with milder symptoms or 'traits' wouldn't need to see a specialist to begin with, but could be helped with practical advice, skills training and support at universities or workplaces. If someone is still struggling after this, then they would be referred for a medical diagnosis. It would help to end the waiting-time lottery and relieve the pressure some feel to pay for expensive private assessments.

Still, with long-term consequences now clear, the earlier help begins, the better. "The best situation for any adult," Thapar says, "is [for the ADHD] to be picked up in preschool. Then they can be supported early before further problems arise. There's quite a lot of evidence that family-focused early-years programmes can help children's mental health in the long-term."

Critics still argue that medical labels can be disempowering. Camilla disagrees. "People critique ADHD diagnoses as just an excuse," she says. "I've had conversations – even with other psychiatrists – who don't realise that they're speaking to someone with ADHD. They've said some pretty horrible things, calling them attention seekers or just looking to justify bad decisions."

Yet, for Camilla, it's not about shirking responsibility, but gaining it. "I'm not fatalistic. I'll always have these tendencies, but that doesn't mean I can't shape my life. I don't strive for perfection – I expect mistakes. But now I know I can reduce the chaos, and that makes all the difference." **SF**

by **DR JACK GOULDER**

Jack is a writer and a medical doctor working in psychiatry.

THE BIG QUESTION

HAS AI GOT AS INTELLIGENT AS IT'S GOING TO GET?

Generative AI burst into the public domain in 2022, with seemingly unlimited potential. But could its abilities be hitting a ceiling already?

by **CHRIS STOKEL-WALKER**

There are few events in technology that can be classed as true 'Big Bang' moments: times when our understanding of the world, and tech's place in it, shifts. The advent of the World Wide Web was one such 'before and after' moment. The release of the iPhone in 2007 was another, bringing about the smartphone revolution.

The November 2022 release of ChatGPT was a similarly seismic shift. Before that, artificial intelligence (AI) was something few people outside the tech world really knew or cared about. But the large language model (LLM) quickly became the fastest-growing app in history and kickstarted what we now call the 'generative AI revolution'.

Revolutions can't always sustain the same momentum, however. Three years on from the release of ChatGPT and despite the harrowing headlines about mass job displacement at the hands of AI, many of us still remain employed, and, reportedly, more than half of Brits have still never used an AI chatbot.

> **"The underlying ability to think, experience and reflect will forever be off-limits to artificial agents"**

Whether the revolution has stalled is debatable, but even AI's keenest disciples suggest things aren't moving as quickly as expected. So, is AI as intelligent as it's ever going to get?

WHAT IS INTELLIGENCE ANYWAY?

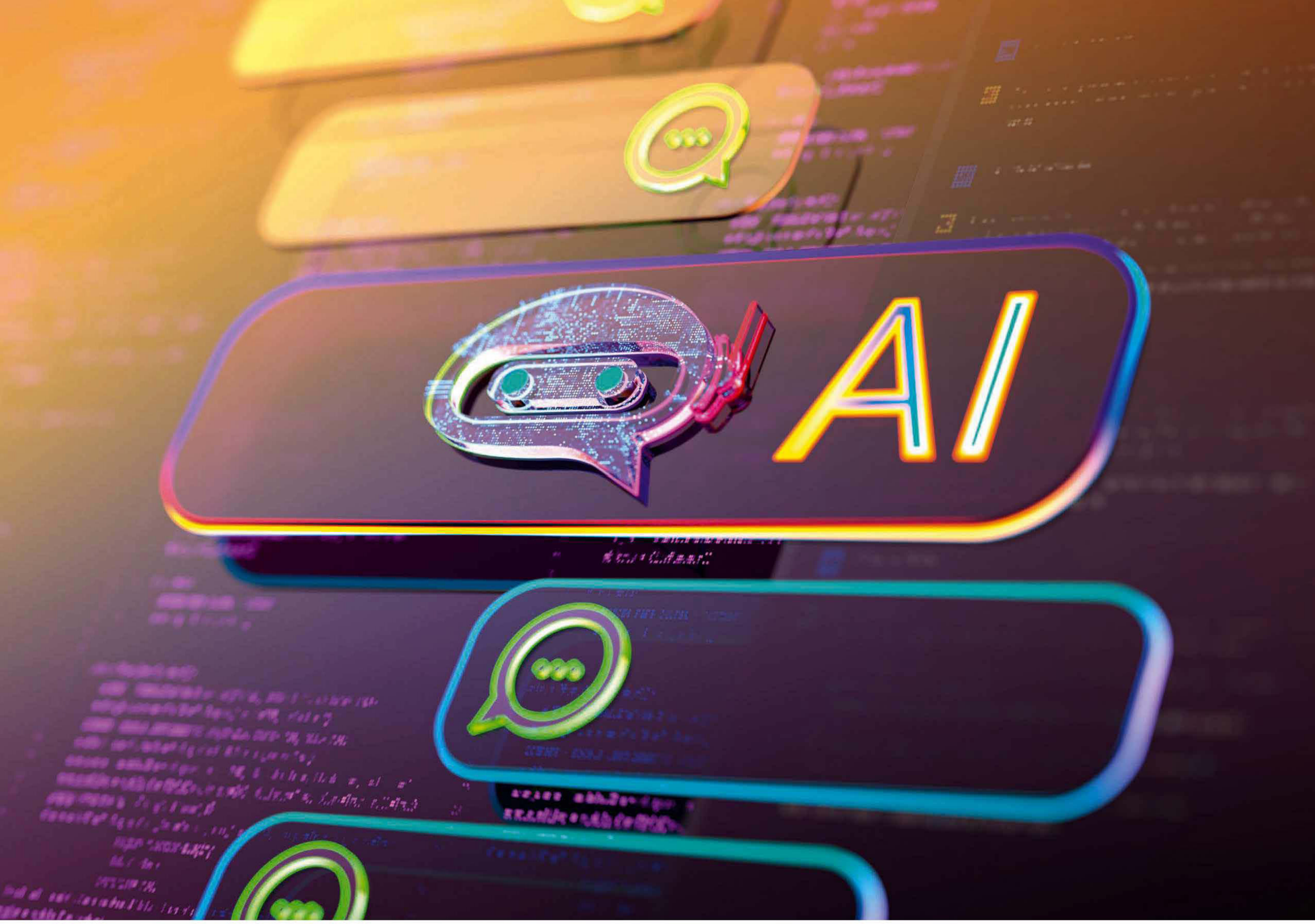
The question of whether AI's intelligence has plateaued depends on your definition of the word 'intelligent', reckons Catherine Flick, professor of AI ethics at Staffordshire University. "In my opinion, AI is not actually intelligent at all, but a programmatic ability to respond to human questions with intelligent-seeming responses," she says.

For her, the answer to whether AI has become as intelligent as it can is yes – because it never was and never can be.

"All that can happen is that we could get better at programming these tools to return an ever-more-deceptive simulacrum of intelligence. But the underlying ability to think, experience and reflect will forever be off-limits to artificial agents," she says.

In part, some of the disappointment around AI comes from a group of AI advocates who suggested AI could do anything a human could do – and do it better – from the moment it was unleashed on the world.

That group included the AI companies themselves and their leaders. Dario Amodei, CEO of Anthropic, the makers of



The full range of AI's applications is being determined, but currently, it's often used like a chatbot or search engine, or to produce text, images and videos

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the Claude chatbot, is one of the loudest backers. He recently suggested AI could develop beyond the limits of human intelligence within three years – though he's previously made similarly bullish predictions that ended up being wrong.

Flick recognises that 'intelligence' when it comes to AI means different things to different people. And if the question is really 'Will AI models like ChatGPT and Claude get even better?', her answer changes.

"Then the answer is probably no," she says. "[They'll probably] get better as other methods are found that can more accurately simulate [a human-style interaction], but they're never going to make that magical step from being a fancy statistical weighting processor of data to actual experiential, thoughtful, reflective intelligence."

Nevertheless, the debate about AI models starting to return less and less powerful improvements is a lively one in the AI industry. OpenAI's highly anticipated GPT-5 model turned out to be a damp squib – largely because the company tried to present it as something superhuman in its pre-release marketing. So, when the slightly more capable model was released, people saw it as underwhelming. For AI naysayers, that's a signal we've already reached a ceiling. But are they correct?

TWO-TRACK SYSTEM

"The perception that AI's progress is plateauing is actually an illusion, shaped by the fact that most people encounter it only through consumer-facing applications like chatbots," says Eleanor Watson, an AI ethics engineer and faculty member at Singularity University – an education company and research facility.

Even then, those chatbots are improving, but often in ways that feel incremental, says Watson. "Like a car getting a sleeker paint job or a better GPS each year," she explains. "What this view misses are the revolutionary changes happening under the hood. In reality, the engine has been fundamentally redesigned and is accelerating at an exponential pace."

While AI chatbots might operate largely the same as they did three years ago for the average user who doesn't dig into the details, AI is being used in a range of applications that it wasn't before, and successfully so. Medicine, for example.

That pace is likely to continue, she reckons, for a number of reasons. One is the sheer might of energy being put behind the generative AI revolution.

According to the International Energy Agency, by 2030 the electricity demand to power AI systems will be greater than what's used for manufacturing steel, cement, chemicals and every other energy-intensive good *combined*.

Tech companies are spending vast sums on data centres to process our AI queries. In 2021, the year before ChatGPT's release, four of the biggest tech companies – Alphabet (Google's parent company), Amazon, Microsoft and Meta (owners of Facebook) – spent just over $100bn (£733bn) on everything needed to house and operate these data centres. In 2025, it's closer to $350bn (£256bn), and expected to exceed $500bn (£366bn) by 2029.

Alongside building bigger data centres with stronger, more reliable sources of electricity to power the models, AI companies are getting smarter with how those models operate.

"The brute-force method of adding more data and computing power still yields surprising gains, but the bigger story is efficiency," says Watson. "Models are becoming vastly more capable. A task that once demanded a sprawling behemoth can now be achieved by a system a fraction of the size, that's cheaper and faster, with capability density rising at an astonishing rate."

Techniques such as rounding numbers, or quantising inputs to LLMs – meaning you reduce how precise the information is in areas that are less important – can all make models more efficient.

> **"An agentic AI can manage your finances, anticipate needs and devise sub-goals toward a larger objective"**

by **CHRIS STOKEL-WALKER**

Chris is a freelance tech journalist who writes for The Guardian, The New York Times, The Economist *and more.*

GET ME AN AGENT

One area of 'intelligence' – if we're defining it as 'efficiency' – that AI still has room to grow into, is in 'agentic' AI use.

This involves shifting what an AI does and how we interact with it, and is still in its early stages. "An agentic AI can manage your finances, anticipate needs and devise sub-goals toward a larger objective," explains Watson.

All the major AI companies, including OpenAI, are integrating agentic AI tools into their systems, which would turn the use of the technology from simple chats into AI-powered co-workers who can independently get on with tasks while you focus on something else. Increasingly, these AI agents are able to labour away independently for hours at a time – something that most people would argue signals the advancement of AI intelligence.

Yet AI agents come with their own challenges. Researchers have already identified issues with agentic AI, which can be hoodwinked into carrying out nefarious instructions through so-called 'prompt injection' attacks, where they're told to carry out commands that could be harmful when they encounter instructions on a website the AI agent believes to be innocuous. For that reason, many companies are keeping tight leashes on these AI agents.

But just the notion that AI can be sent away to do tasks on autopilot suggests that there's room to grow. That, alongside the investments in computing power and the continual turnover of AI products, suggests that AI isn't stalling. Far from it.

"The smart bet is on continued, exponential growth," says Watson. "The [tech] moguls are right about the trajectory, but they tend to underplay the governance and safety challenge that must scale alongside it."

Liquid-cooled servers in London are testament to the AI boom, with computing power set to grow tenfold in two years

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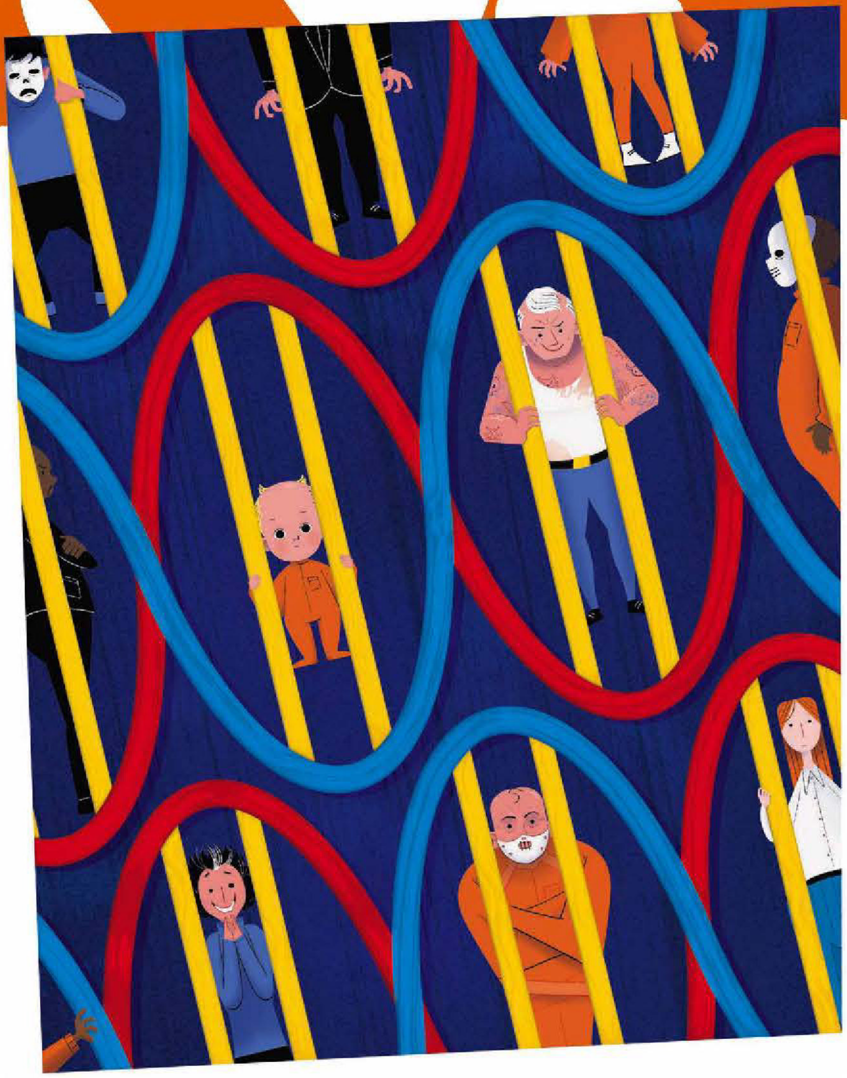
Norway is Never the Same Twice

The beauty of Norway doesn't waver between seasons, it simply finds new ways to astonish you. From dreamy summer evenings under the Midnight Sun to the dramatic snow covered landscapes surrounding the fjords during winter; striking scenes are in abundance all year round.

Q&A

YOUR QUESTIONS ANSWERED



ELLIOT OWENS, ST ALBANS

IS PSYCHOPATHY BORN OR BRED?

This is a trickier question than people might assume. Not least because, for many years, psychopathy was thought to be very mysterious – and in a lot of ways, it still is.

There are lots of mental, neurological and personality disorders that people fear. For the most part, this is due to ignorance and flawed assumptions.

While this is also true for psychopathy – a personality disorder – the negative reactions it causes are somewhat more understandable. After all, psychopathy is regularly linked with callousness and emotional detachment, as well as deviant behaviour, manipulation and criminality.

Less than one per cent of the general population show indicators of psychopathy, but this rises to 25 per cent (that's one in four) of the prison population.

So, what causes psychopathy? Are psychopaths born this way, or are they created by (presumably very negative) life experiences? As the cliché goes, is it due to nature or nurture?

Despite science's best efforts, personality itself is hard to pin down and define, so personality *disorders* remain similarly nebulous and tricky to define. This applies as much to psychopathy as any other disorder, as demonstrated in Jon Ronson's book *The Psychopath Test*, which explores how even tried and tested methods for identifying psychopathy can be – to put it diplomatically – hit-and-miss.

However, while it may be more difficult to identify than many realise, few would argue that psychopathy isn't a genuine condition. And recent advances have shed some light on the matter.

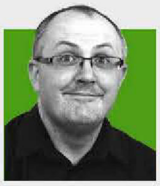
> "HOW OR WHY CERTAIN PEOPLE'S BRAINS END UP THIS WAY IS HARD TO SAY"

AMY ARTHUR
Health & Wellness

PETE LAWRENCE
Astronomy

LUIS VILLAZON
Everyday science

DR CLAIRE ASHER
Weird science



DR DEAN BURNETT
Psychology

IAN TAYLOR
Biology

PROF PETER BENTLEY
Technology

DR HELEN PILCHER
Animals

DR HELEN SCALES
Marine biology

The use of brain scanning technology, like fMRI (functional Magnetic Resonance Imaging), has provided evidence that psychopathy corresponds to fundamental differences in brain structure.

The scans revealed that psychopathy is linked to anatomical differences in the brain systems that connect structures in the prefrontal lobes, the posterior cingulate cortex and key parts of the temporal lobe.

The functions of these regions are incredibly varied, but this particular combination is heavily linked to emotional processing. These differences may be disrupting the brain's typical ability to recognise, encode and understand emotional information.

As emotion is such a vital aspect of human cognition, an inability to process it could help to explain a few of the classic traits of psychopathy. For example, not being able to grasp how emotions affect other people could lead to the signature loss of empathy, as well as placing a higher value on purely rational thinking and having a reduced awareness of the consequences of their actions.

How or why certain people's brains end up this way is hard to say. But there are also genetic factors that seem to play a role in the development of psychopathy.

While a person's environment and life experiences may contribute to or intensify psychopathy or psychopathic tendencies – as well as certainly leading to distorted emotional processing and related issues – such things aren't known to be able to shape both brain structure and genetics to such a consistent degree.

All of the evidence, therefore, suggests that psychopathy is born, more than bred.

Why such a mental disorder would even evolve in the first place, though, is a different question entirely. ***DB***

GETTY IMAGES X2 ILLUSTRATION: ROBIN BOYDEN

SALLY THOMPSON, PETERBOROUGH

WHAT'S THE SMELLIEST THING IN THE WORLD?

As the human nose can have wildly different sensitivities to odour molecules, smells are difficult to measure objectively.

Judges have ranked the French cheese Vieux-Boulogne as the smelliest, but you can't directly compare this to other strong-smelling foods, such as durian fruit (right).

For simple chemicals, you can measure smelliness in terms of the minimum detectable concentration of it. The worst-smelling chemical, thioacetone, is detectable at concentrations of just 0.02 parts per billion. When it was first distilled in 1889, it almost immediately caused vomiting and unconsciousness to everyone within a half-mile radius. ***LV***

KAITLIN FINLEY, CAMBRIDGE

COULD I GET PHONE SIGNAL ON THE MOON?

The Moon is getting busier these days, with several missions planned and underway by private ventures and international collaborations. With this in mind, there's a greater need than ever to have a reliable communication network.

Intuitive Machines, who built the first commercially funded lander to touch down on the Moon in 2024, set a goal of putting a Nokia cellular network on the Moon in 2025. This would have been a 4G cellular network enabling communication between the lander and two vehicles.

Unfortunately, it didn't work out this time – the lander made it to the Moon, but fell on its side and wasn't able to achieve its objective. Nevertheless, future attempts using Nokia's hardened electronics might later be used for a 5G network for lunar habitats and spacesuits. That's one small step for man, and lots of Moon emojis. ***PB***

THE GIANT PHANTOM JELLYFISH

Conjure in your mind a giant, deep-sea predator, and I bet there's a colossal squid lurking in there, perhaps with an even bigger sperm whale chasing after it. But there are plenty of other enormous hunters prowling the dark depths that still remain great mysteries to science, including the aptly named giant phantom jellyfish, *Stygiomedusa gigantea* (from Greek words translating roughly as the "giant jellyfish of the underworld").

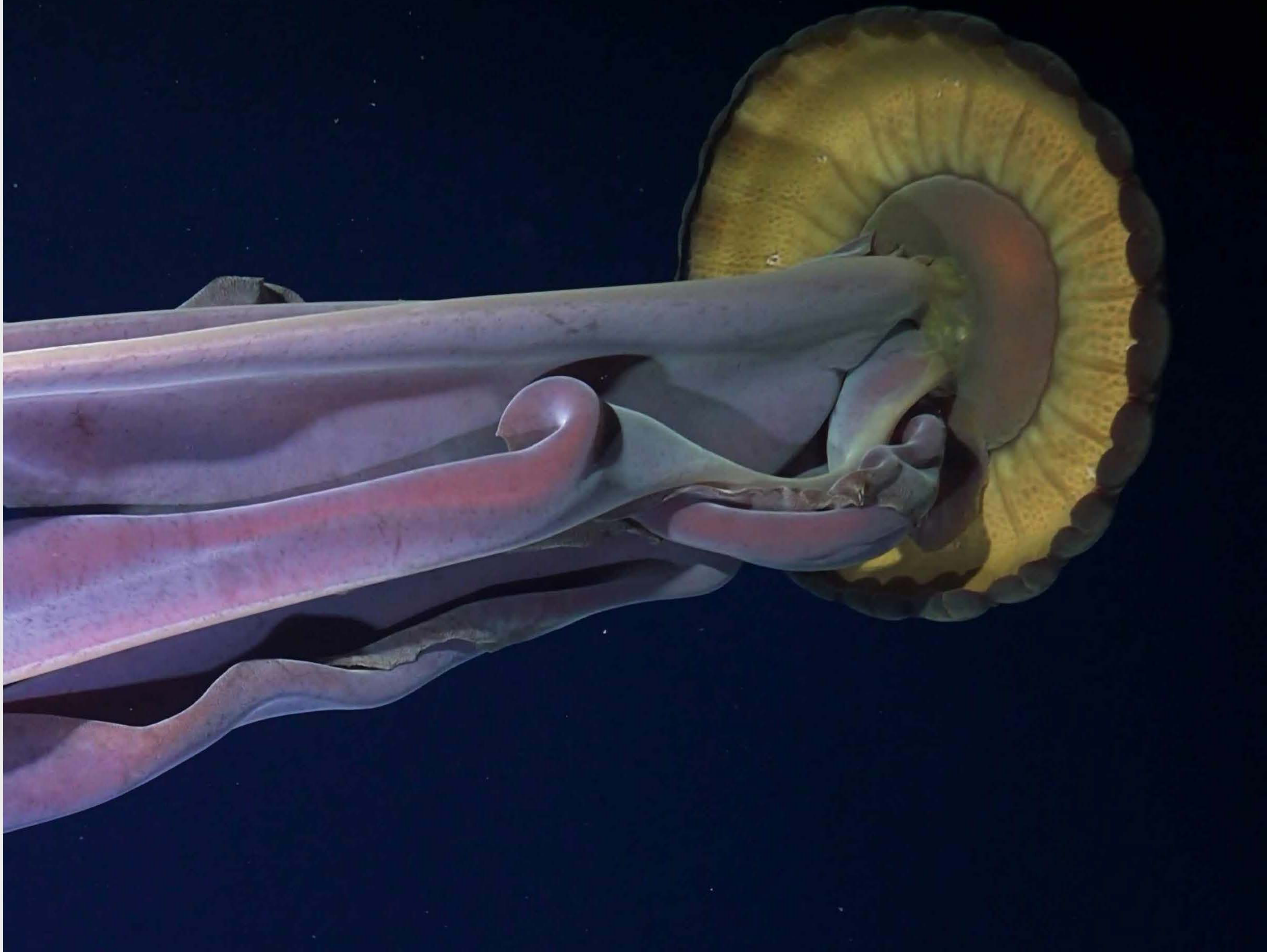
These impressively proportioned jellies are generally a deep crimson colour, with a smooth rounded bell (or 'head') a metre (3ft) or more wide, and fringed in a rippling skirt. Four ribbony arms trail behind for up to 10m (33ft) – long enough that if one of these jellies was sitting in the back row of seats in a London double-decker bus, it would be able to tap the driver on the shoulder.

Giant phantom jellyfish are members of the Ulmaridae family, together with more familiar species such as moon jellies.

Unlike their close cousins, however, the phantom jellies don't have stinging cells to hunt and paralyse their prey. Instead, they grab small fish and zooplankton in their great long arms, and shove them into their mouths.

Scientific explorers first dragged up a specimen of a giant phantom jellyfish at the end of the 19th century, and the species was officially named in 1910. In the decades since then, and despite their size, there have been just over a hundred recorded encounters of phantom jellies.

Rare sightings have been made all around the world, in the Atlantic, Pacific, Indian and Southern Oceans, where they generally occupy extreme depths. They're known to roam more than 6km (4 miles) down.



> **"MORE OF THESE MYSTERIOUS JELLYFISH HAVE BEEN SPOTTED BY TOURISTS THAN BY SCIENTISTS"**

In 2025, scientists on the Schmidt Ocean Institute's ship the *R/V Falkor (too)* were exploring Antarctic seas, where a massive iceberg had recently calved off an ice sheet, uncovering a huge swathe of the sea that, until then, had been out of researchers' reach.

Using the remotely operated vehicle *SuBastian*, they discovered an ecosystem that had been thriving on the seabed under the ice, full of animals like octopuses and giant sea spiders. They also obtained spectacular footage of a giant phantom jellyfish drifting past.

More of these mysterious jellyfish have been spotted by tourists than by scientists. High-end Antarctic cruise ships are equipped with personal deep-diving submersibles to take holidaymakers on excursions beneath the waves. Several passengers have been lucky enough to encounter a giant phantom jellyfish and have returned to the surface with ghostly video footage on their mobile phones.

A scientific paper published in 2023 reported on these sightings, which took place mostly around the coasts of the West Antarctic Peninsula between 80–280m (262–918ft) underwater. To put this in perspective, that's roughly in between the heights of Big Ben and the Empire State Building.

Why these giant phantom jellies range closer to the surface in the icy cold waters of the Southern Ocean is just another, as yet, unsolved mystery. ***HS***

SCHMIDT OCEAN INSTITUTE, GETTY IMAGES

RADHIKA BHATIA, VIA EMAIL

SHOULD I KEEP MY CAR KEYS IN A FARADAY BOX?

Potentially, yes. The invention of keyless entry means we can unlock our cars upon approach, something particularly helpful when you want to open the boot, but have your hands full of shopping. But relying on an electromagnetic signal (rather than a good, old-fashioned key) to tell your car when to lock and unlock means that, with the right kind of technology, it's possible for someone to intercept and exploit that digital communication.

There were nearly 130,000 vehicles stolen in the UK between April 2023 and March 2024 and more than half of household incidents involved the thief manipulating a signal from a car key without ever having to get their hands on it.

This is only a problem for cars that have passive keyless entry: where the key only has to be in *range* of the car for it to unlock, no button-pressing needed. These entry systems work by sending out a signal that, when nearby, the car can detect.

The exact distance depends on the car manufacturer, but theoretically, when your key is in the house and your car is on the driveway, the two are far enough apart that the signal won't reach.

Yet thieves can obtain devices that extend the reach of your key's signal. This is called a relay attack, because typically more than one device is involved. Thief number one will be positioned outside your house somewhere within range of your key, which is sending out a signal in case it's near your car. They'll use their device to capture the exact data within the signal, which is then relayed to their partner in crime, who is holding a second device next to your car. The car recognises the key's unique signal and dutifully unlocks.

The best way to avoid this scenario – aside from trading in your car for a low-tech model – is to stop your key from emitting a signal outside of the times when *you* want to unlock your car.

Some manufacturers have introduced 'sleeping fobs' for newer models, which have motion-sensor technology that'll stop sending signals when the key is likely not needed. Others have developed keys that use a bandwidth that's much harder to relay. It may be that one day, we'll do away with keys altogether, using biometric technology based on fingerprints or facial recognition to unlock our vehicles.

But, for now, if your car uses keyless entry and can't be put in sleep mode, you might want to find another way to block the signal. This is where a Faraday box, or pouch, can help. Lined with a conductive material, these containers prevent signals from coming in or out. You could also try wrapping your key in tin foil, or putting it in the fridge or in the microwave – keeping the latter turned off, of course! ***AA***

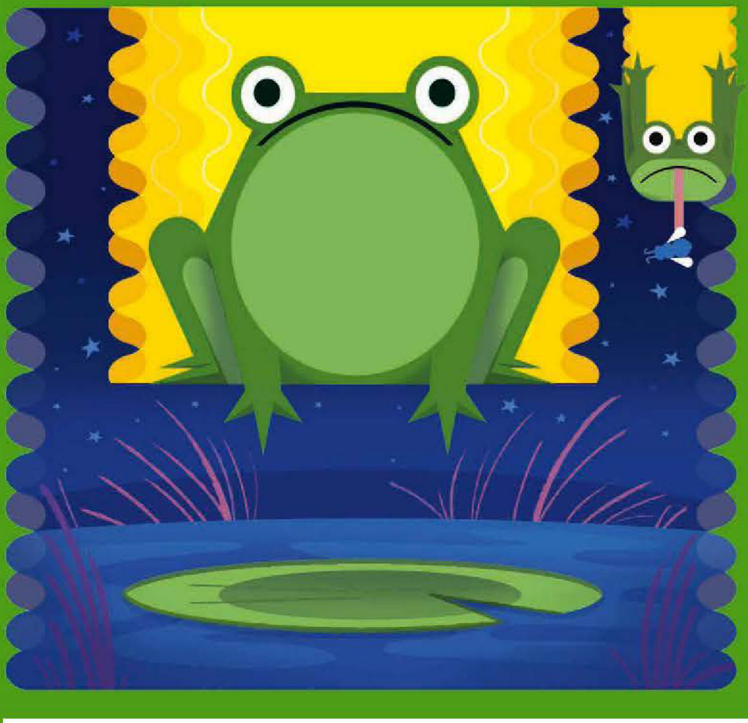
BARNEY REED, LICHFIELD

WHAT ARE SOME OF THE SPOOKIEST EXPERIMENTS WE'VE EVER DONE?

Although science often advances through tried-and-tested methods, sometimes scientists have to find creative ways to test their hypotheses. Here are five of the wackiest science experiments ever conducted…

LEVITATING FROGS

Everything has its own magnetic field, however small. This means that, theoretically, any object would be repelled by a sufficiently strong magnet. Scientists dramatically demonstrated this fact in 1997, when they used a high-powered magnet to levitate a live frog. The frog was unharmed by the experience, but research into this phenomenon (called 'diamagnetic levitation') has many potential applications, from medical imaging to space technology.



TURNING WATER INTO METAL

Ancient alchemists would have marvelled at this 2021 experiment, which briefly turned water into a shiny, metallic substance.

Metals conduct electricity because they contain 'free electrons', which aren't bound to an atom. In contrast, pure water isn't conductive because the electrons are tightly bound to their atoms. Theoretically, water is conductive under extremely high pressure, because the molecules are squished together, creating an overlap between their outer electron orbits.

Scientists were able to create metallic water *without* high pressure by exposing droplets of sodium and potassium (both are alkali metals that tend to 'donate' electrons to other atoms) to water vapour. The water condensed into a microscopically thin layer around the droplet and, as the metals donated electrons to the water, it turned into a shimmering golden ball, with the properties of a metal.

SLOWING THE SPEED OF LIGHT

In 1999, scientists used a technique called 'quantum interference' to slow the speed of light to just 17m (56ft) per second – that's roughly 61km/h (38mph).

When light is refracted through a transparent substance, such as water or a glass prism, it travels more slowly, but some of the light is absorbed in the process. This limits how much we can slow light down.

To overcome this, researchers super-cooled sodium atoms to almost absolute zero (-273.15°C or -459.67°F) and then applied a polarised laser beam, preventing light from being absorbed when passing through.

When the researchers sent a pulse of light through this setup, it slowed to 1/20,000,000th of its normal speed. This experiment advanced our understanding of how light operates at the microscopic level.

GETTY IMAGES X3 ILLUSTRATIONS: ROBIN BOYDEN, PETE LAWRENCE

PAINTING COWS

In 2019, scientists painted black cows with white stripes. Their aim was to test the hypothesis that zebras' bold black-and-white stripes help to deter biting flies.

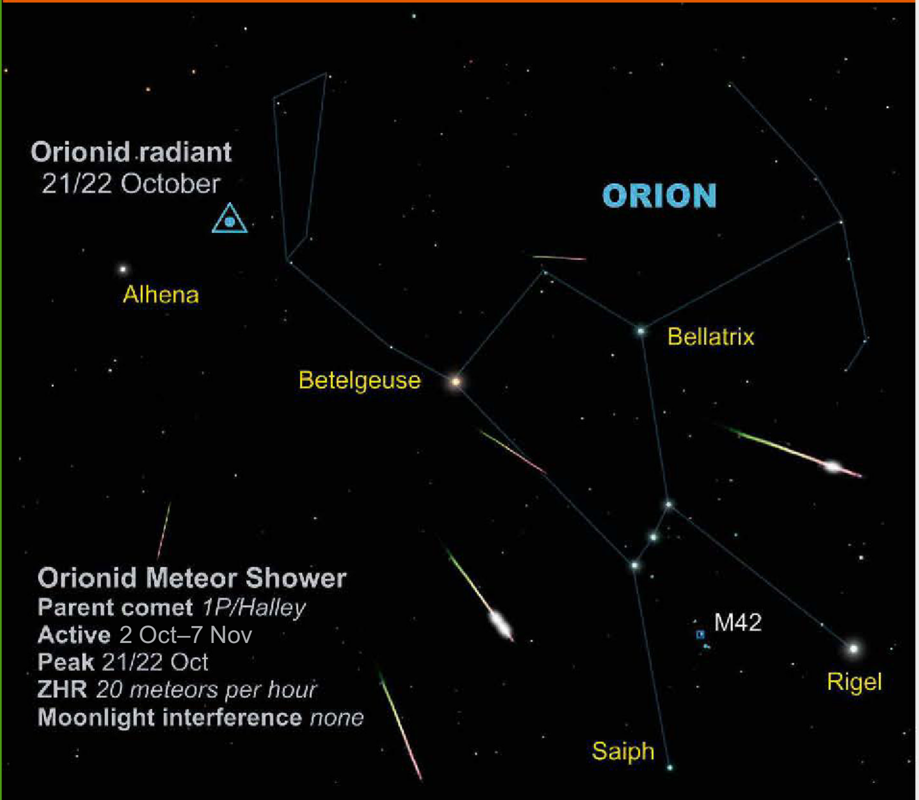
And indeed, they found that cows with white stripes suffered 50 per cent fewer fly bites than black cows and spent less time fending off flying insects. The results offer a potential way to defend livestock from biting insects without using harmful pesticides.

UNRAVELLING THE MYSTERIES OF WOMBAT POO

Wombats have the dubious accolade of being the only creature that produces cube-shaped poo. To understand how they achieve this feat, in 2018 researchers dissected the digestive tracts of two wombats. They found that the final section of the intestine has alternating regions of stiffer and softer muscles.

Mathematical modelling showed that rapid contractions of this stiff muscle, followed by slower contractions of the soft muscle, could form corners, giving wombat poop its distinctive shape. Bizarrely, this discovery could aid the development of new manufacturing techniques. ***CA***

ASTRONOMY FOR BEGINNERS



Orionid Meteor Shower
Parent comet *1P/Halley*
Active 2 Oct–7 Nov
Peak 21/22 Oct
ZHR *20 meteors per hour*
Moonlight interference *none*

HOW TO SEE THE ORIONIDS (EVIDENCE OF HALLEY)

WHEN: OCTOBER

Between 2 October and 7 November, Earth passes through some of the fine dust debris strewn around the orbit of Halley's Comet. Over time, dust is released when the comet returns to the inner Solar System and spreads it around the entire orbit.

Halley is estimated to have been around for at least 16,000 years, perhaps even as long as 200,000 years, returning roughly every 76 years. At present, it's about as far away as it can get, 35 times further than the average distance between Earth and the Sun.

The encounter with the comet's dust is a reminder of its existence and happens twice a year. Once in early May, producing the Eta Aquariid meteor shower, and again at the start of the third week in October, giving us the Orionid meteor shower.

Though the Moon is great to observe, it's not always welcome. Its light can be a nuisance, especially when looking for faint events such as meteor showers.

Thankfully for this year's shower, a new Moon will coincide with the peak of Orionid activity – on the night of either 21 or 22 October – meaning no moonlight interference at all.

The most meteors you can expect to see (the shower's zenithal hourly rate, ZHR) is 20 per hour. Trails will appear to emerge from a region of sky near the red supergiant Betelgeuse in the constellation Orion. This is known as the 'shower radiant', and is caused by our perspective looking up from Earth.

To enjoy the show, locate a dark area and look roughly two-thirds up the sky. Any direction works, but due south has Orion slowly creeping into view throughout the night. Observe from 11pm BST through to dawn if you can, as the shower is best in the early hours. ***PL***

by PETE LAWRENCE
(@Avertedvision)
Pete is an astronomy expert and presenter on The Sky at Night.

WATCH *THE SKY AT NIGHT* ON BBC FOUR AND BBC IPLAYER

ALINA MAYS, VIA EMAIL

CAN ANIMALS SMELL DEATH?

When one little *Caenorhabditis elegans* worm dies in a petri dish, any others in the vicinity wiggle as far away as possible, prompting speculation that the eyeless invertebrates are responding to some sort of 'death scent.'

Researchers have recently discovered that the reaction is triggered by specific chemicals, released as cells break down, that are detected by key sensory neurons. This not only prompts the worms to move away, but it also makes them reproduce more quickly and then die sooner. Flies also die more quickly in the same situation, so all in all, it's best to avoid the scent of death. ***HP***

LOCHLAN BOOTH, DURHAM

DO I HAVE ALEXITHYMIA?

We can all struggle to find the words to explain ourselves, but if you regularly experience feelings that you can't identify, you might have alexithymia.

As well as having difficulty naming emotions, people with alexithymia may not be able to easily distinguish between feelings and bodily sensations. Imagine you're walking down the street and spot your old school crush. Your chest tightens and your heartbeat races. These physiological changes could indicate nervousness or excitement. Someone without alexithymia would be able to quickly tell which emotion they were experiencing, but a person with alexithymia might not know how they were feeling, or they'd have to look for clues within their memories, or in the context of the situation before they could name their emotion.

As identifying emotions is an important part of emotional regulation, alexithymia can make it hard for people to manage intense negative or positive feelings.

It's also a personality feature, rather than a distinct syndrome or disorder. We don't know its exact cause, though research has found both genetic and environmental factors. Around 13 per cent of the population experiences alexithymia in some way and some studies point to higher rates in men than in women.

Alexithymia is also a common feature of neurological diseases, like epilepsy or after a stroke, and can be acquired after trauma or a brain injury. In 2018, psychologists reviewed past studies into alexithymia and found that there was a large overlap with autism. As many as one in two autistic people may struggle with alexithymia.

While there are no treatments for the condition, it has been suggested that it's possible for people to improve their emotional awareness through practice. This includes training games that connect bodily sensations with corresponding emotions, and efforts to expand your 'emotional dictionary', so that you have more descriptions to choose from when trying to decipher your inner feelings. ***AA***

THOMAS GREENE, DERBY

SHOULD I START SNIFFING ROSEMARY?

Is there any truth to the Shakespearean phrase 'rosemary for remembrance'? Actually, yes. Research does suggest that the herb aids cognition and memory, and may even slow down the progression of Alzheimer's in the brain.

While there's only a relatively small number of studies, a 2020 review of the literature concluded that rosemary is "memory boosting". In one particular study, healthy participants who worked in a cubicle that smelled of rosemary did better on recall tasks, like memorising a list of words, than those working in an odourless cubicle.

Excitingly, rosemary may have other benefits, too. Research in animals suggests that the herb could reduce some of the symptoms of Alzheimer's disease thanks to two chemical compounds found in the plant: carnosic and rosemarinic acid.

Carnosic acid is known to promote human brain cells to produce a nerve growth factor, and rosemarinic acid has been shown to inhibit an enzyme called acetylcholinesterase (AChE) in mice.

Drugs that inhibit AChE are already being used to manage Alzheimer's disease – expect to see a lot more rosemary research coming soon. ***AA***

MIRIAM RUSSELL, HULL

HOW MANY ORGANS COULD I SURVIVE WITHOUT?

The annals of medical history prove that the average human meat sack is surprisingly resilient. The literature is dotted with extraordinary case studies, such as a French man found in 2007 to be living without 90 per cent of his brain. The 44-year-old was leading a normal life when doctors discovered he had an extreme case of hydrocephalus, where brain tissue is replaced by cerebrospinal fluid.

It's a startling example of biological redundancy and adaptation, where surviving tissues take on the function of lost tissue (in this case, through neuroplasticity). Something similar can happen in paired organs such as the lungs, kidneys or testes. If one is lost, the surviving organ can take on the function of two.

In other cases, astonishing medical technology keeps people alive after the loss of essential organs. A young American man, for example, carried a functioning artificial heart around in a backpack for 555 days after his own was removed but before he could receive a transplant. In 'empty chest cases', surgeons remove a patient's heart and lungs, and their functions are replaced by a life-support system called extracorporeal membrane oxygenation (ECMO).

There are also examples where people have lived without multiple organs. Some patients with stomach cancer need to have multiple digestive organs removed, which can include the complete stomach, spleen, pancreas, small intestine and colon. In these cases, they survive with a combination of enzyme replacement, modified diet and intravenous feeding, plus insulin replacement.

Other internal organs that you can live without include the gallbladder, bladder, thyroid and appendix. It's unclear if there's a limit on how many organs a person could live without at any one time, although losing several in any one incident would risk death by blood loss, infection or sheer trauma. ***IT***

SCIENCE PHOTO LIBRARY, GETTY IMAGES X3 ILLUSTRATION: ROBIN BOYDEN

FIRST CONTACT
Starwatchers
Jeanne Baker

WRITE IN

The writer of next issue's Question of the Month will receive **two hardback popular science books**: *First Contact* and *Starwatchers* **worth over £40!**

MARIE CHELMSFORD, VIA EMAIL

HOW MANY SPIDERS ARE IN MY HOUSE?

Pest control companies will often give a figure of 40 spiders in an average house, but it's hard to find anything in the published literature that directly backs this up. A 2016 study of 50 houses in North Carolina, US, found cobweb spiders in 65 per cent of all rooms sampled, but this was looking at biodiversity, and didn't count the number of individual spiders.

If a typical house has 5 or 6 rooms, plus hallways, the average figure would be around 10 spiders per room, which seems like a lot. To add some research of my own, I've just hoovered my entire house (a rare event) and only found 26 spiders. But that's just the parts of the house that we can easily scrutinise. If you consider under the floorboards, behind the fridge, the loft, the garage and so on, there could easily be that many more still hiding.

If we consider the average density of spiders *outdoors*, a widely cited figure from Nyffeler and Birkhoffer's 2017 paper is 131 spiders per square metre (11 square feet) of land. That's of the order of 10 quadrillion spiders worldwide, or about a million spiders for every human.

A typical house actually has relatively little spider food available. But it also has almost none of a spider's main predators, such as centipedes and birds, so each spider may live longer indoors than out.

Spiders also lay anything from 10–250 eggs at a time and house spiders may lay as many as five clutches per year. Less than one per cent will reach adulthood, but even so, if we count baby spiders in our household population census, the figure may be as many as a couple of thousand spiders at any one time. ***LV***

QUESTION OF THE MONTH

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CROSSWORD

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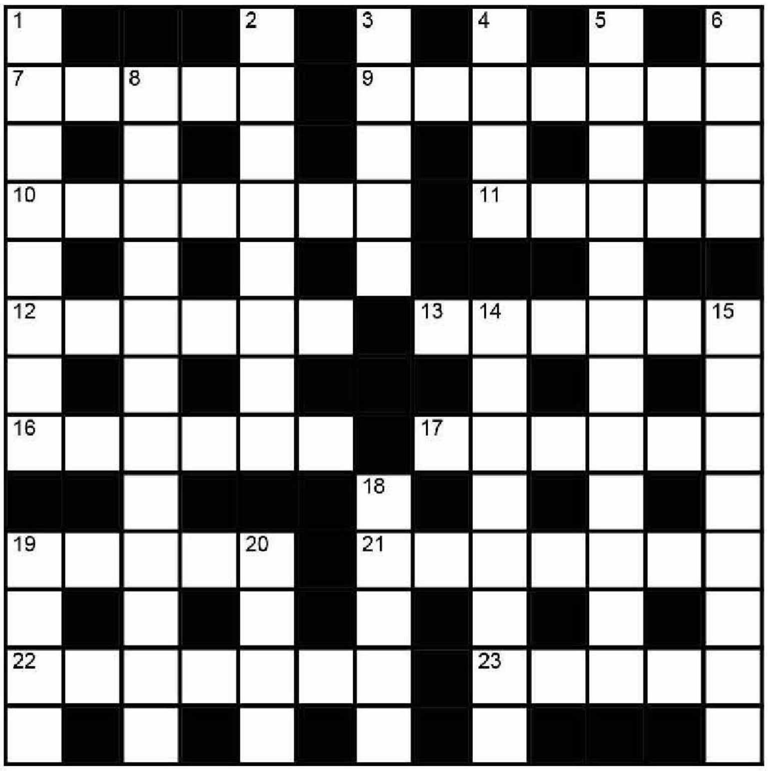


ACROSS

7 Wise men with key to a form of sorcery (5)
9 Almost mislay remedy about shutdown (7)
10 Scrap occasion for some music (7)
11 Mark has registered a knack (5)
12 Summit making strange claim and getting cross (6)
13 Rip-off boy in gaol (6)
16 Follow member to a bend (6)
17 Child at home with loud worker (6)
19 Slender, returning to husband in high spirits (5)
21 Holiday right for a warship (7)
22 Large broadcaster outside is modest (7)
23 Laces some trousers (5)

DOWN

1 Hugged me back and provided support (8)
2 Start to vacate it, possibly (8)
3 Personnel pursuing small fastener (5)
4 Two weeks not having dark time in castle (4)
5 Roman play (6,6)
6 Fifty-two cards on the floor (4)
8 Very keen to request a judge's directive (7,5)
14 Give up right to space a little bit (8)
15 Revealing person performing a turn first (8)
18 Alarming situation makes school head worry (5)
19 Tom's broken more than half (4)
20 Conceal the skin (4)

ANSWERS

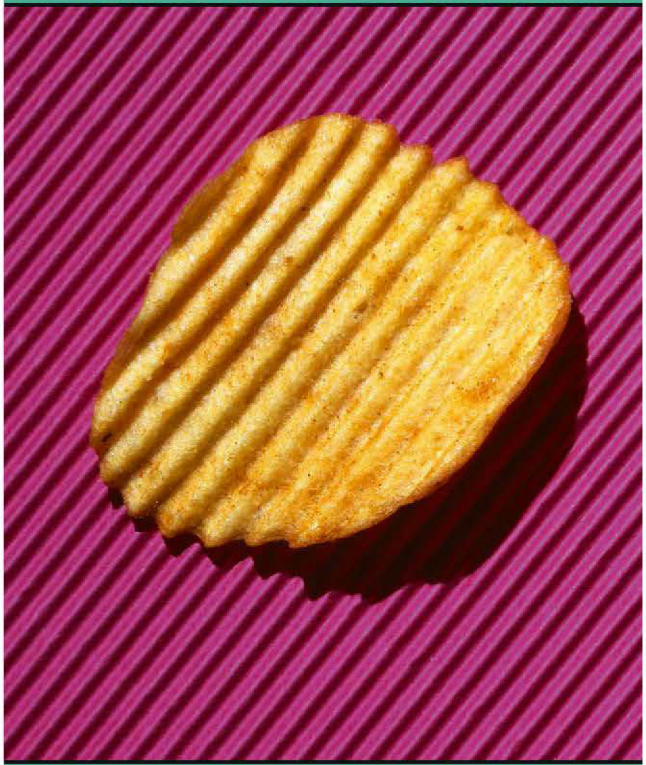
For the answers, visit **bit.ly/BBCFocusCW**
Please be aware the website address is case-sensitive.

GETTY IMAGES

NEXT ISSUE

THE HARD TRUTH

The everyday snacks and staples stacking your cholesterol higher than you think



PLUS

RECLAIM YOUR VOICE

People-pleasing can hijack decisions, confidence and your inner voice

SEX CHANGE

The remarkable science behind animals that transform from male to female or vice versa

ON SALE 11 NOV

SF

BETTER LIVING THROUGH SCIENCE

ILLUSTRATION: CHARLIE PADGETT

MENTAL STRENGTH

Could a supplement used by athletes and bodybuilders help treat depression?

by **IAN TAYLOR**
Ian is a freelance science writer and the former deputy editor of BBC Science Focus.

With the possible exception of caffeine, there's no (legal) performance-enhancing substance more potent, trusted or well-studied as creatine. In the last three decades, sports science has shown it can significantly increase an athlete's strength, muscle mass, speed and power.

In recent years, though, researchers have built a persuasive case file for creatine's role in wider health and wellbeing. Studies have shown it can improve metabolic health and cognitive performance. It can aid recovery from serious injury and facilitate healthy ageing. There's also growing evidence that it can help not just physical strength, but mental toughness, too.

In 2024, a review concluded that creatine supplementation had multiple positive effects as an adjunctive treatment for depression. Papers have found, for example, that when combined with SSRI antidepressants, the effects of the medication can be stronger.

Similarly, a pilot study in early 2025 looked at creatine combined with cognitive behavioural therapy (CBT) in patients with depression. The study was small, but it was randomised, double-blind and placebo-controlled. Researchers found that although CBT by itself helped lower depressive symptoms, the effects were significantly stronger in those who had also taken creatine during the eight-week study.

"Depression is a widespread disorder and we need new therapies that are more effective and work faster," says study author Dr Riccardo De Giorgi, a clinical lecturer in psychiatry at the University of Oxford.

He says that creatine is an interesting candidate partly because it's so practical. "It's quite inexpensive, very widely available and it's what's called a nutraceutical – like a dietary product."

Although creatine occurs naturally in our bodies, we get most of it from our diets – mainly animal products. The supplement version often used by athletes is called creatine monohydrate, which is available as a powder or gummy sweets.

Once it's in the body, creatine serves as a kind of back-up battery for our cells. It's converted into a molecule called phosphocreatine, which can itself be broken down and used as energy. It's also involved in the production of adenosine triphosphate (ATP), which is another energy source for our cells.

It's this role in the body's energy systems that could underpin creatine's wide range of benefits – even for mental health.

"Creatine's role in restoring energy stores within our muscles is quite well established," says De Giorgi. "Now, the idea is that creatine might be doing something similar within the brain."

"We think that there's at least a subset of people with depression, for whom their depressive symptoms may be very much related to low energy levels and fatigue. For those people, it's possible that an intervention like creatine might reach the brain and have a positive impact on symptoms."

De Giorgi stresses that the work is preliminary and much bigger studies are needed. But even within his own paper, the backup energy system idea offers an intriguing explanation. People engaging with CBT might have better cognitive resources to engage with therapy, he says.

The theory is one part of an emerging field in mental health research known as metabolic psychiatry. It's the idea that mental illness could be linked to obesity, diabetes and other metabolic conditions. If there's a link, then perhaps nutritional and other metabolic interventions offer a new kind of therapy, "not related to the usual chemicals in the brain like serotonin and dopamine."

Creatine isn't the only nutritional supplement to be studied as a possible therapy for depression. A number of studies have found links between vitamin D levels and depression, with one 2024 review finding that vitamin D supplements had a significant effect in lowering depressive symptoms. Studies have also shown that magnesium supplements can lower depression scores.

As with creatine, more research is needed, but it's a reason for optimism in the fight for mental health. Around one in six people in the UK suffer from depression in a given week and it's estimated that 30 per cent of cases are treatment-resistant. Creatine and other supplements might just give us the strength of mind we need. **SF**

"IT MIGHT REACH THE BRAIN AND HAVE A POSITIVE IMPACT"

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